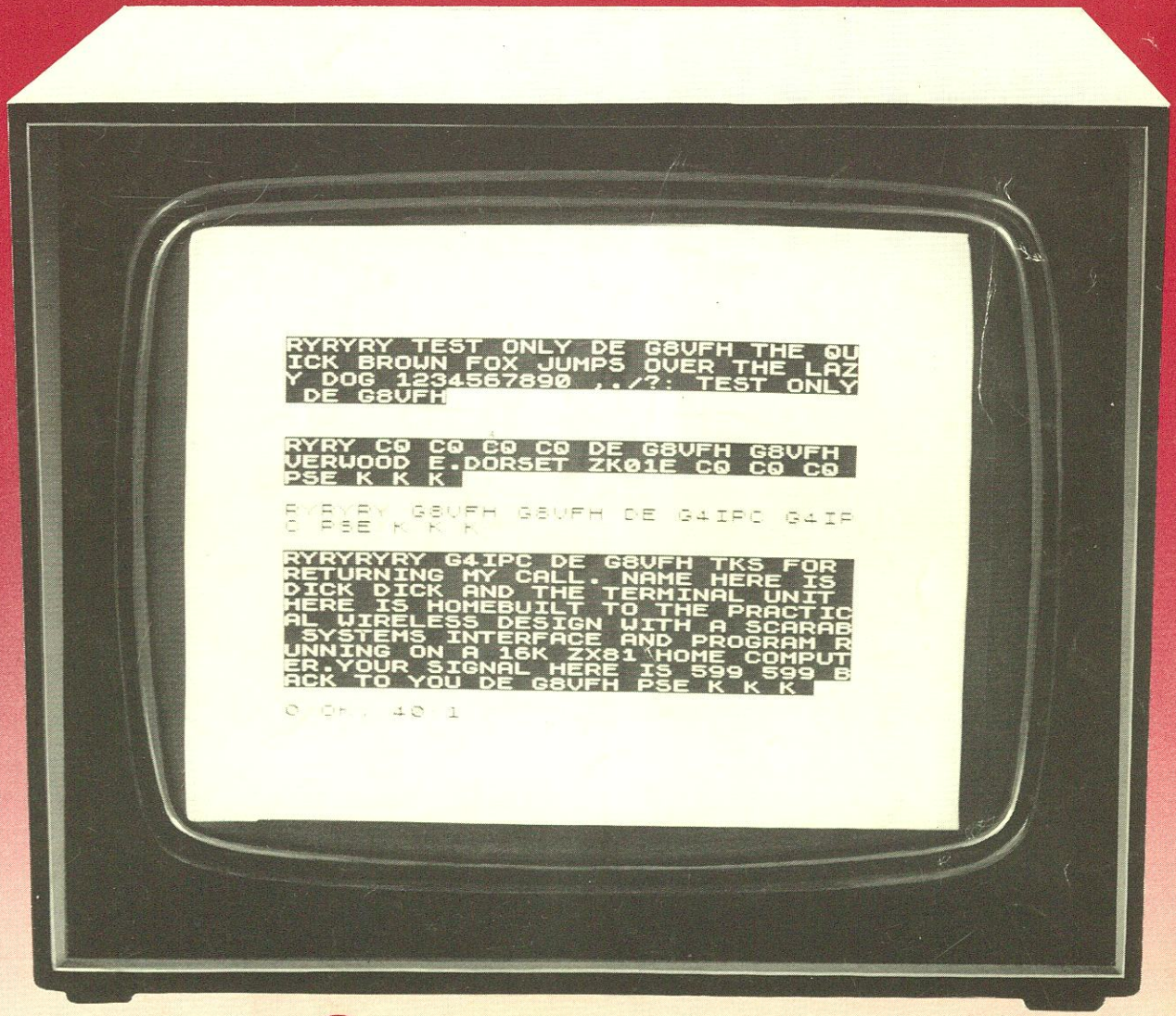
INTRODUCING £1·00

RTTY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ACK TO YOU DE G8VFH PSE K K K

another Practical Wireless publication

INTRODUCING

RTTY

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introducing RTTY part 1

Jeff MAYNARD G4EJA

Telegraphy (of which RTTY is a development) was the first electrical communications technique to gain widespread acceptance. Samuel F. B. Morse brought together a number of then existing technologies and his own invention—Morse code—to provide the first telecommunications system. For many years the hand key, linked to another with copper wire, was the only means of direct remote communication.

Many brains worked through the turn of the century on improving the Morse code system. A cross between typewriter and a telegraph system was invented by Joy Morton and Charles L. Krum and the resulting Morkrum machine adopted by Associated Press in 1915. Concurrently, one Edward Kleinschmidt devised his own similar machine, and in 1925 he merged his company with Morkrum. Five years later this company was absorbed by AT & T and christened The Teletype Corporation. The machine name Teletype was an amalgam of telegraph and typewriter and is, incidentally, still a registered trademark of The Teletype Corporation. The use of the word to describe any mechanical printer is, strictly speaking, illegal, though like Hoover, it has tended to become part of everyday speech. The pedants amongst us may prefer to use the common abbreviation TTY which is not protected by trademark or copyright legislation.

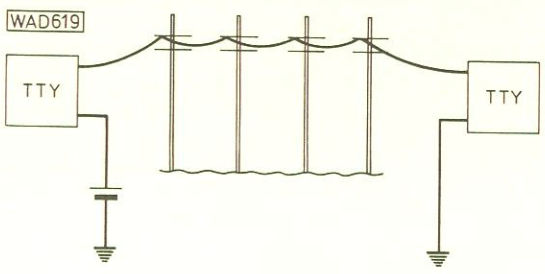

Fig. 1: The basic TTY system

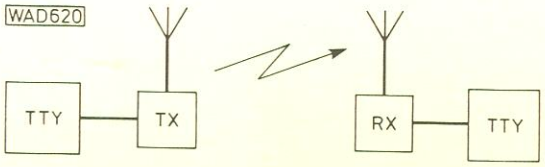

Fig. 2: The basic RTTY system

The developments of remote TTY printing terminals outlined above took place in respect of land-line signalling (Fig. 1) and this should be borne in mind when reading the description of printer interfaces in Part Two of this series.

During World War II, when the modern war machine demanded volumes of textual communications to armies in the field, it became apparent that the land lines hitherto used to link TTY terminals could be replaced by radio transmissions with only minor interface modifications (Fig. 2). Thus RTTY (radio TTY) was born. There then followed parallel developments of RTTY and TTY systems, the latter manifesting itself as the international telex system. The widespread use of TTY machines in commerce and military applications inevitably led to their appearance on the surplus market and hence to their use by amateurs.

RTTY Code Format

The decoding and coding of Morse traffic by machine is complicated by the variable character length and the use of five different signalling units (dot, dash and three lengths of spaces). TTY on the other hand uses only two signalling elements—mark and space—and, because all characters are the same length, there is no significance to any inter-character spacing (there being no intra-character spacing).

Computer enthusiasts will immediately see the possibilities for processing what is basically a binary system. RTTY was developed before the microprocessor of course, and it is therefore more by good luck that computer techniques can be applied to the system. Such methods will be discussed in the final article of this series.

The two RTTY signalling conditions are known as Mark and Space. Mark is the normal or idle condition of the line (the various methods of representing Mark and Space in RTTY will be outlined later). A character is represented by a combination of marks and spaces and defined in the particular code in use. In order that the start of a character can be correctly identified it is always preceded by a space. Thus from the idle condition there will be mark-to-space transition; the space will last for a defined unit of time (depending on the overall system speed) and be followed by a combination of marks and spaces (each of the same defined unit of time) specifying the particular letter or number being transmitted. The character is finished with a stop pulse—always a mark—which is one-and-a-half units of time. So that is the theory of the code; now let us take a detailed look at the code format and the timing.

The Baudot Code

In theory at least, any code could be used to represent characters in RTTY (e.g., ASCII, EBCDIC, ISO and so on). In practice RTTY used the same code as telex—the International Five-Unit Code also known as CCITT No. 2 and Baudot (from the gentleman who devised it). As the name implies, the Five-Unit code uses a combination of five elements (marks and spaces) to represent each character. The total number of combinations available is therefore 32 (2^5). It is clear that this is insufficient for normal use, since the alphabet and a few control characters (such as carriage return and line feed) will need 32, leaving no combinations available for figures, punctuation marks and so on.

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Character		Signal element				
Letter shift	Figure shift	1	2	3	4	5
A	–	●	●			
B	?	●			●	●
C	:		●	●	●	
D	wru	●			●	
E	3	●				
F	%	●		●	●	
G	@		●		●	●
H	£			●		●
I	8		●	●		
J	bell	●	●		●	
K	(	●	●	●	●	
L	)		●			●
M	.			●	●	●
N	,			●	●	
O	9				●	●
P	0		●	●		●
Q	1	●	●	●		●
R	4		●		●	
S	'	●		●		
T	5					●
U	7	●	●	●		
V	=		●	●	●	●
W	2	●	●			●
X	/	●		●	●	●
Y	6	●		●		●
Z	+	●				●
Letters shift		●	●	●	●	●
Figures shift		●	●		●	●
Space				●		
Carriage-return					●	
Line-feed			●			

Notes:
wru means 'who are you' and is used in telex.
All space is not used.

● = Mark

WAD621

Fig. 3: The full Baudot International Five-Unit Code (CCITT No. 2)

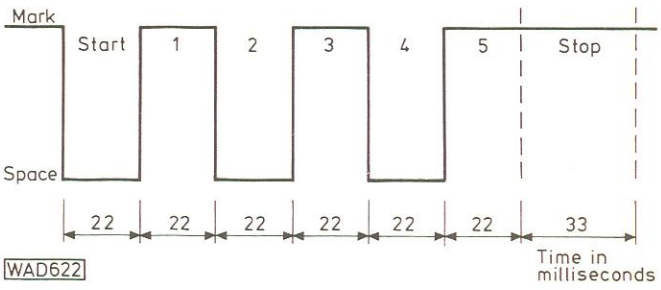

Fig. 4: Composition of an RTTY character

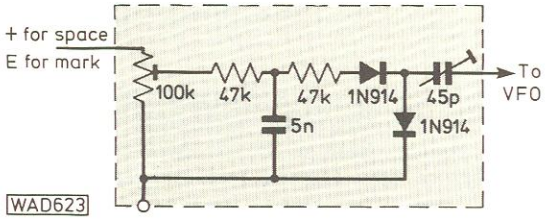

Fig. 5: A simple circuit to produce FSK on a v.f.o.-controlled transmitter

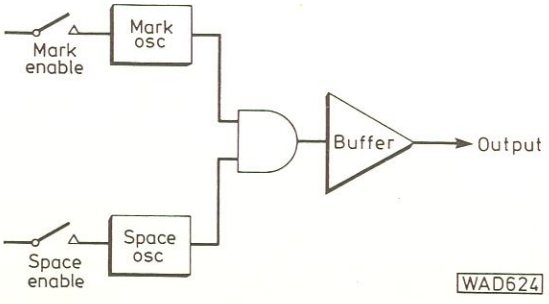

Fig. 6: General principle of an AFSK generator

This problem was neatly circumvented by Mr Baudot who introduced shifts. Thus a TTY machine can be in letter shift or figure shift. When in letter shift, any following keys denote their respective letter; when in figure shift, each key denotes a figure or punctuation mark. To change from one shift to another it is necessary to press the appropriate shift key.

The aspiring RTTY enthusiast should bear the shift system in mind; when tuning into an RTTY signal that appears unintelligible it may be that the receiving machine is in the wrong shift. For example a machine in figure shift will print:

:1 :1 :1 :1

when tuned to a station transmitting:

CQ CQ CQ CQ

The full Baudot code is shown in Fig. 3, to which the following comments apply:

1. Some characters (e.g., line feed) are the same in both shifts.
2. The code pattern is the same as the hole pattern across five-unit paper tape.
3. WRU means who are you and is the signal used in telex to request the remote terminal to send its identification (answerback).
4. All space is not a valid code.

Speeds

The speed of an RTTY signal is expressed in baud, where one baud is equal to one signal element per second. We have already seen that a single RTTY character consists of: a start element; five code elements; $1\frac{1}{2}$ stop elements, giving a total of $7\frac{1}{2}$ elements per character. If then the signal was to be one character per second the RTTY rate would be 7·5 baud.

Most commercial RTTY is at 50 baud (telex being 75 baud) whilst amateur RTTY enthusiasts have standardised at 45·45 baud. Each code element is therefore 22 milliseconds long (60 divided by 45·45) and a complete character is 165 milliseconds long. Fig. 4 illustrates the basic RTTY character timing. From the idle mark state the character always starts with a 22ms space; this is followed by five character elements (10101 in the example) each also 22ms in length; the character is terminated by a stop pulse—always mark—of 33ms (one-and-a-half elements) in length. The amateur RTTY speed corresponds to six characters per second or (for average five-character words plus inter-word spaces) to 60 words per minute; this nomenclature is used by North American amateurs in preference to baud rates.

The timing of RTTY signals is important both in receive and transmit if correct decoding is to be guaranteed. Note that, unlike some modern data transmission codes, Baudot does not contain any mechanism for error checking. Distortion in the received pulse chain can lead to erroneous decoding. The two most common forms of distortion (which can arise from the transmission medium or the originating terminal) are bias and end distortion.

Bias distortion displaces the space-to-mark transition. Lengthening the mark by advancing the transition is called marking bias whilst lengthening the space by delaying the transition is called spacing bias. End distortion displaces the mark-to-space transition. Marking end delays the transition giving a long mark and spacing end advances the transition giving a long space. The RTTY enthusiast will normally have to contend most with characteristic distortion—that is distortion introduced by the transmission medium.

Converting TTY to RTTY

To achieve a radio TTY link it is necessary to replace the hard-wired d.c. path by some form of coded radio transmission. Two methods of doing this are commonly used:

1. FSK (frequency shift keying) shifts the transmitted carrier frequency for each mark to space transmission.
2. AFSK (audio frequency shift keying) modulates a carrier with two different tones, one each for mark and space. This technique is also known commercially as VFT (voice frequency telegraphy).

The shift between the two frequencies is most important. The receiving unit (discussed next month) will use sharply tuned filters and will not decode for a wrongly spaced shift. The shift also determines the maximum transmission rate and the bandwidth required, although these are topics beyond the scope of the current article.

Table 1

Band	Frequency	Modulation
80m	3·60MHz ± 20kHz	
40m	7·04MHz ± 5kHz	
20m	14·09MHz ± 10kHz	
15m	21·10MHz ± 20kHz	
10m	28·10MHz ± 50kHz	
4m	70·56MHz	
2m	144·6MHz	FSK
2m	145·3MHz	AFSK
70cm	432·6MHz	FSK
70cm	433·3MHz	AFSK

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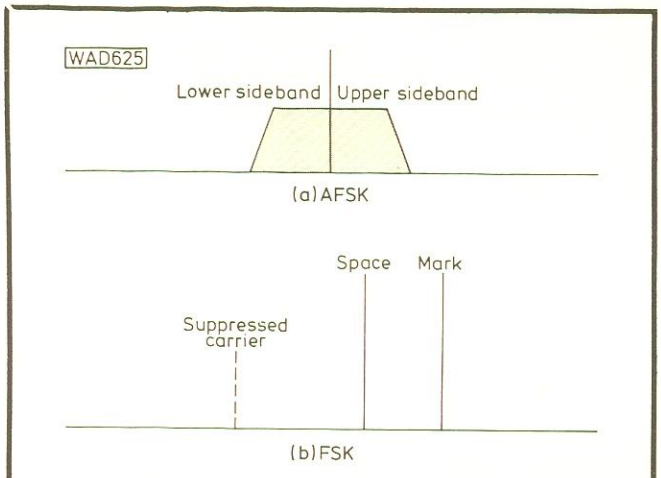

Fig. 7: Frequency spectra of (a) an AFSK signal (b) an FSK signal

The shift for amateur RTTY is 170Hz whilst most commercial traffic is at 850Hz.

FSK can be achieved by "pulling" the v.f.o. of a transmitter as shown in Fig. 5. The positive voltage appearing for a space will cause the diodes to forward conduct, placing the capacitor across the v.f.o., thus reducing its frequency (the capacitor being adjusted for the appropriate shift).

AFSK is generated by switching between two audio oscillators (for amateur RTTY of 1275 and 1445Hz), or by pulling a mark oscillator down to the required space frequency. The detailed methods of producing AFSK will be covered in a later article but Fig. 6 shows the general idea. The output of the AFSK oscillator is fed to the microphone input of a transmitter.

The frequency spectra for FSK and AFSK are shown in Fig. 7, which demonstrates clearly that FSK is more efficient (in terms of spectrum utilisation and signal power). However AFSK is much easier to produce. A nice compromise is available, because feeding AFSK to a s.s.b. transmitter will cause a signal closely akin to FSK to be radiated. This is the normal method adopted on the h.f. bands and for v.h.f. DX working. Local RTTY nets on v.h.f. and upwards tend to use AFSK with f.m. transmitters.

Equipment

Traditionally, the RTTY enthusiast's shack has been instantly recognisable from the smell of oil and the clanking of gears. Old electro-mechanical machines—such as from Creed, Siemens and Teletype—have been the mainstay for RTTY for years (and can still be bought for £10–£20). Recently RTTY has been invaded by the microprocessor revolution and many more stations are now operational using Pets or Apples or home-brew systems. The use of microprocessors for RTTY will be covered later in this series.

Where to find RTTY

The IARU band plan recommendations for RTTY are shown in Table 1. Tuning around these frequencies, particularly on 80m and 20m, will almost always produce the rhythmic "jingle bells" of RTTY (using 170Hz shift and 45·45 baud). The BARTG (British Amateur Radio Teleprinter Group) transmits RTTY news bulletins on 80m on Sunday mornings. An RTTY repeater (GB3PT) transmits on channel RB12 (433·30MHz) from Barkway in Hertfordshire. A German amateur, DL1WX, operates a "store and forward" type of RTTY repeater around 14·075MHz.

introducing RTTY part 2

Jeff MAYNARD G4EJA

To convert the output from a receiver loudspeaker to a form suitable for driving a terminal and (on transmission) to convert the output of the terminal into an AFSK signal, requires what is known as a terminal unit. Fig. 8 shows a block diagram of such a unit for reception only (transmission is dealt with later).

The first and last blocks (limiter and terminal unit) are largely incidental to the main process of mark/space detection and are therefore dealt with first. Unless stated otherwise, the reader can use the circuit ideas given with any of the discriminators/tone detectors shown later.

The limiter in its simplest form consists just of two back-to-back diodes across the input (Fig. 9). This literally limits the input voltage swing to 0·6V. Following the limiting diodes, it is quite usual to see some form of band-pass filter to eliminate some of the inevitable QRM associated with RTTY reception. With the ready availability of i.c.s, it is simplest today to opt for an active filter whose centre frequency is set mid-way between the mark and space frequencies (i.e., at 1360Hz). The National Semiconductor publication *Linear Applications, Volume 1* suggests a two-stage active band-pass filter, which is shown in Fig. 10 with suitable values for this requirement. The gain is approximately 15 (23dB) and the *Q* about 25. This filter can be inserted between the limiting diodes and the next stage (some type of discriminator or tone detector). A bypass switch to take the filter out of circuit is a useful addition to any terminal unit.

The LM3900 used in this circuit contains a further two op. amps. which could be used for another band-pass filter if a two-shift terminal unit is required, or as part of an active filter tone detector (as described later).

Interface

One of the most difficult areas of RTTY for the newcomer to grasp is that of terminal interfaces or magnet drivers. The latter name comes about because the older electro-mechanical types of terminal require the terminal unit to activate some form of selector magnet. It is the need to drive this magnet coil, with an inductance of perhaps 4 henries, that necessitates the use of an 80 volt signal. The large inductance coupled with a resistance of about 250 ohms gives a time constant (L/R) of 16ms (assuming the magnet pulls in at about 12·5mA). Since each RTTY element is only 22ms long this is clearly unacceptable. To reduce this time the inductance can be reduced (impractical) or the resistance increased. For a time constant of 1ms the resistance must be 4kΩ. At this figure the applied voltage required to maintain the magnet holding current of 20mA is (from Ohm's Law) 80 volts.

Driving Systems

Two types of magnet driving systems are used—single current or unipolar, and double current or polar. A single current system, generally operating at 120 volts, allows current to flow, at about 60mA, through the selector magnet for the mark condition. The space condition is when no current flows.

In a polar system (also known as 80-0-80V) it is the direction of current flow that represents the RTTY signal. When the terminal input is negative with respect to earth it is in the mark condition; when it is positive with respect to earth it is in the space condition.

These two types of signalling are illustrated in Figs. 11(a) and 11(b) respectively. Some of the more modern terminals available have added to this confusion with requirements such as ±12V, 12V single current, ±6V and of course TTL.

To minimise the reader's difficulty in understanding the prime function of a terminal unit of demodulation, all the circuits that follow are given with TTL compatible output. In order that the user may use these circuits with his own particular terminal a number of conversion circuits are shown as follows:

Fig. 12: TTL to 120V single current
Fig. 13: TTL to 80-0-80V double current
Fig. 14: TTL to ±12V

Note that in Fig. 13 the double current or polar signalling is achieved by reversing the flow from a single polarity supply. The convention for TTL compatible RTTY is that a mark is represented by 1 (+5V) and a space by 0 (0V or ground).

Demodulator

Now we have an input limiter with optional band-pass filter that can be connected directly to a receiver loudspeaker, and a method of driving any of the current popular terminals. All that is now necessary is to demodulate the incoming tones to a TTL compatible signal (mark = 1, space = 0). When received on a correctly tuned receiver the loudspeaker output for an RTTY signal will be a mixture of 1275 and 1445Hz tones (assuming an amateur transmission).

The two-tone method of demodulation uses a pair of filters, one for each tone. In many earlier units these were LC filters as shown in Fig. 15. The coils employed are standard 88mH centre-tapped loading coils as used by the Post Office and obtainable from a number of sources. This type of demodulator is aligned by selecting an appropriate capacitor or combination of capacitors to tune each coil whilst an accurate tone is fed to the input.

The output of the op. amp. will swing between the positive and negative rails as a signal is present within the passband of the respective filters. This circuit has been used by many amateurs throughout the world after reading *RTTY The Easy Way* published by the British Amateur Radio Teleprinter Group (BARTG).

The availability of op. amps. at low prices makes an active filter two-tone demodulator an attractive proposition.

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Fig. 8: Receiving terminal unit block diagram

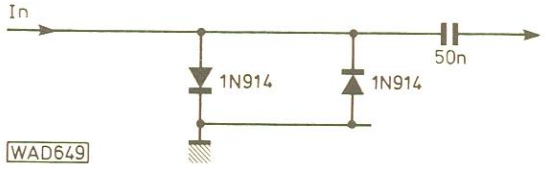


Fig. 9: Terminal unit input limiting

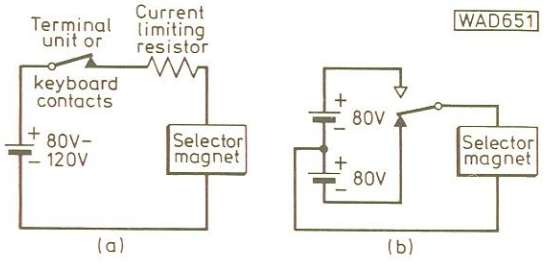


Fig. 11: (a) Single current signalling. (b) Polar or double current signalling

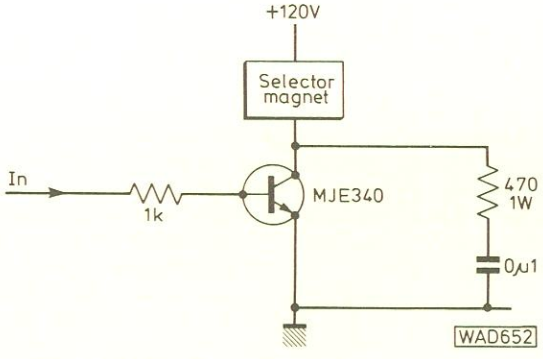


Fig. 12: A TTL to single current interface

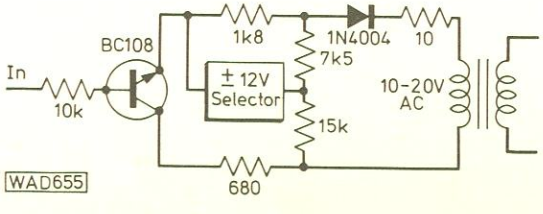


Fig. 14: A TTL to ±12V interface

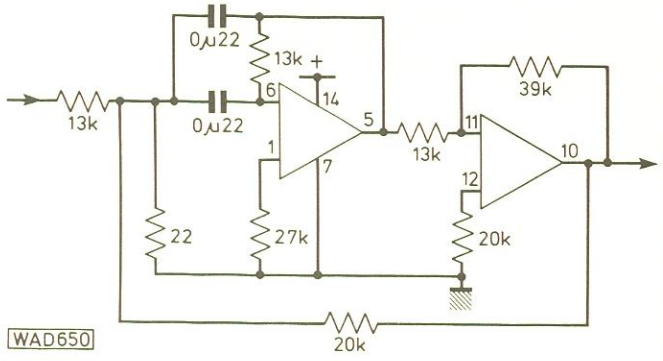


Fig. 10: Active band-pass filter

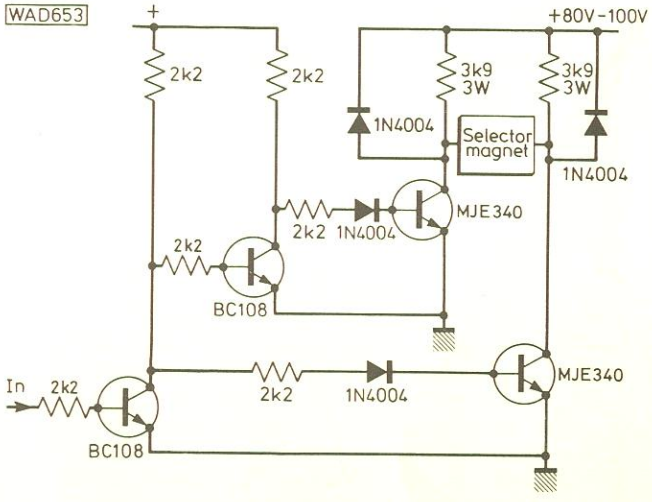


Fig. 13: A TTL to double current interface

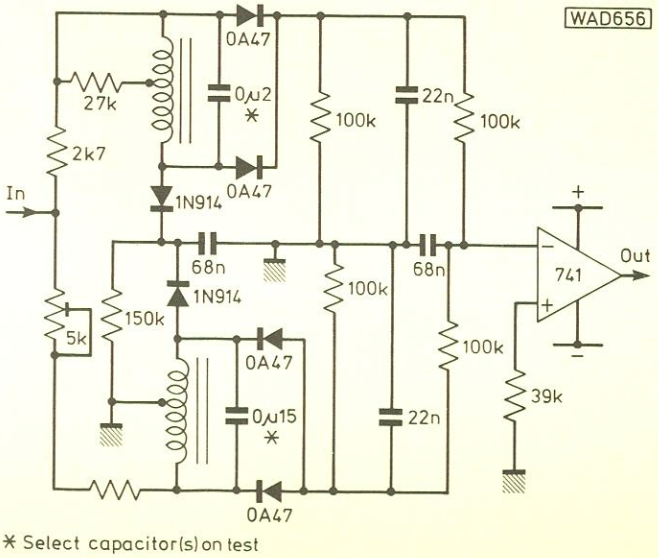
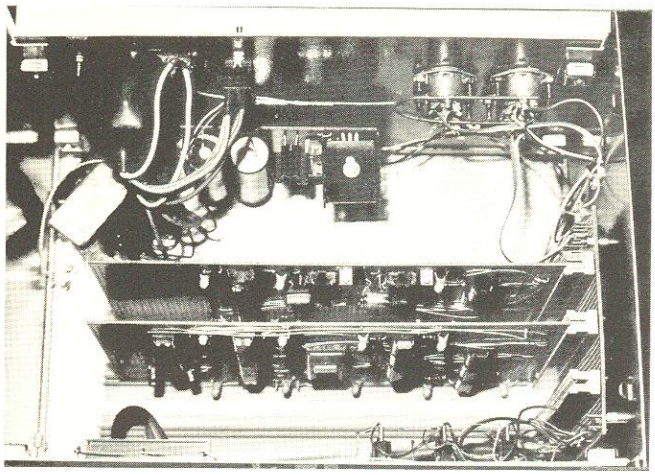


Fig. 15: A passive filter demodulator



Interior of the author's terminal unit, showing the way in which plug-in boards are used to facilitate experimental work

Fig. 16 shows such a circuit as breadboarded by the author. The frequency for each filter (mark and space) is adjusted by means of the 4·7kΩ preset with an accurate input tone.

Phase Locked Loop

The simplest type of demodulator is constructed with the aid of a phase locked loop (p.l.l.), with the NE567 being the most popular. This particular circuit will change output state when a frequency within its capture range is applied to the input. The centre frequency and bandwidth of the capture range are set by a few external components.

If a p.l.l. is set to detect the mark frequency (1445Hz), then at any other time it will output a space condition. Thus a simple unit can be constructed that requires to detect only one tone (its absence being assumed to indicate the other tone). Fig. 17 shows a simple p.l.l.-based demodulator developed by the author. The reader should note that with the addition of input protection diodes and

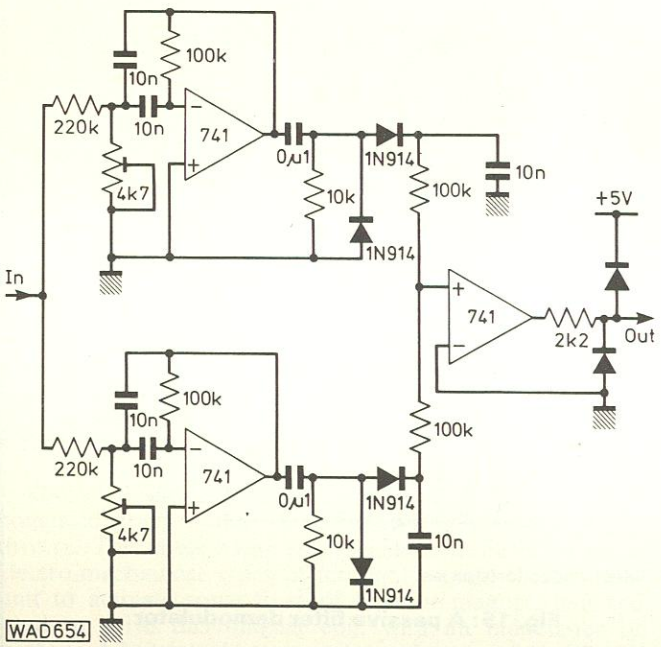


Fig. 16: Active filter demodulator

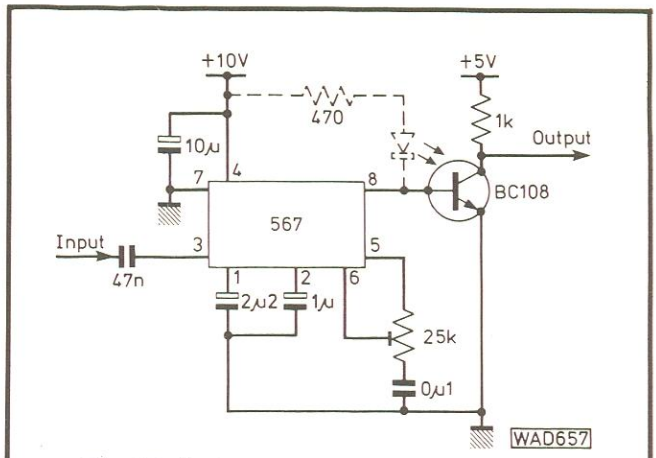


Fig. 17: A phase-locked loop demodulator

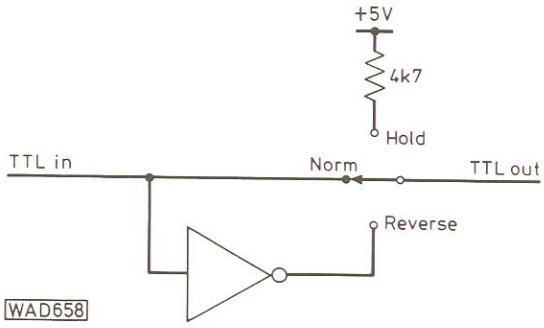


Fig. 18: Hold—Normal—Reverse switching

power supply, this circuit provides a complete RTTY demodulator. The centre frequency of the p.l.l. is set by the 25kΩ preset potentiometer, which should be of the multi-turn type.

If the terminal unit is to be used to copy different shifts then it is only necessary to switch in another preset tuned to the new frequency (mark tones for 850Hz shift signals are at 2120Hz).

Adjustment is quite simple and can be accomplished in one of two ways. If a frequency counter is available, the free running frequency of the p.l.l. is set to 1445Hz (with no input and the counter connected to pin 5). Alternatively, feed a 1445Hz signal into the p.l.l. and adjust the preset until the optional mark-indicating l.e.d. (shown dotted) illuminates. Continue adjusting until the l.e.d. extinguishes, then set the preset midway between these points. The p.l.l. should now be free running at 1445Hz.

The measured bandwidth of the prototype unit was 160Hz at 1445Hz centre frequency. Thus the output will be mark for an input frequency in the range 1365–1525Hz. Any other input frequency will cause a space condition on the output, so that some older terminals will "clatter" when tuning across the band. The simplest way to avoid this is to include a mark-hold switch somewhere in the system; this can usefully be combined with a reversal switch (to copy the transmission of a station sending mark for space and vice-versa) as shown in Fig. 18.

To avoid this "clattering" (which can be very annoying in the presence of c.w. signals) two approaches are possible. The first is the introduction of an "anti-space" circuit between the p.l.l. output and the voltage converting tran-

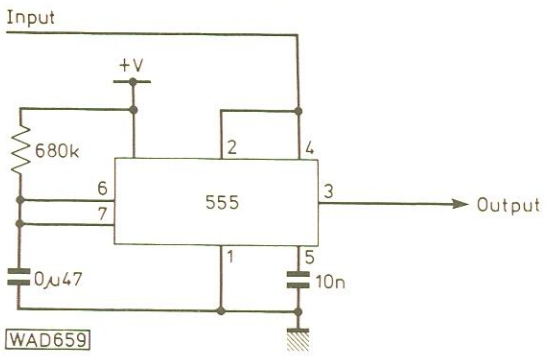


Fig. 19: An "anti-space" circuit

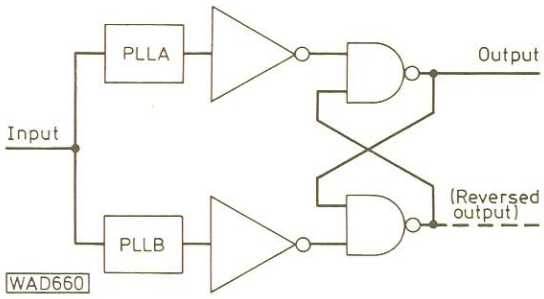


Fig. 20: A twin p.l.l. demodulator

sistor of Fig. 18. Such a circuit, based on a 555 timer, is shown in Fig. 19. This circuit (first suggested by VE4CM) passes normal RTTY signals, but if a space longer than about 300ms appears at the input the output will switch to mark and prevent further "clattering".

The second solution is the provision of a second p.l.l. decoder tuned to the space frequency. The output of the decoders is used to set and reset a flip-flop (Fig. 20). After a mark condition is encountered the unit will only revert to space if the second p.l.l. (identical with Fig. 17 but tuned to 1275Hz) detects a tone within its passband.

Using the circuits described above, the reader can put together a useful terminal unit. It is quite a good idea to develop the unit in stages; starting with the p.l.l. demodulator and progressing to the input filter and then the anti-space features.

The author's terminal unit is built using plug-in boards to a multi-way bus so that new ideas, for say a filter, can be breadboarded and tested within the total system without building a complete unit.

Readers interested in copying commercial RTTY Transmissions are warned that neither the Broadcast Receiving Licence nor the UK Amateur Licence permit the reception of such signals (a number of successful prosecutions have been brought in the last couple of years). However the DTI Radio Regulatory Department have indicated that permission can be granted for reception of commercial short-wave RTTY, provided permission is previously obtained from the various press agencies. Interested readers should write to the DTI at Waterloo Bridge House, Waterloo Bridge Road, London SE1 8UA.

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introducing RTTY part 3

Jeff MAYNARD G4EJA

We have already seen in Part One of this series that the simplest method of generating RTTY for transmission is with an AFSK unit. This can then produce AFSK or FSK by modulating the appropriate transmitter. Accordingly, it is not proposed to discuss any FSK circuits in detail. Various suggestions for producing AFSK are given below; however, before that is done it will be helpful to consider interface circuits again so that the AFSK units need only be designed for TTL-compatible input operation.

The most common terminal output arrangement is the two-way switch biased to mark as shown in Fig. 21. In a TTY system this could be arranged with −80V on the mark contact and +80V on the space so that the tongue switched between these two values. It is just as easy, however, to arrange for the tongue to be grounded and the mark and space contacts used to switch a flip-flop as shown in Fig. 22 (which also serves to debounce the input).

Conversion of 80V signals can be done simply by using a potential divider as shown in Fig. 23. A safer method is to isolate the 80V supply completely from the TTL circuitry by means of an opto-isolator as shown in Fig. 24.

In these methods only the +80V supply is needed and is connected to the space contact. An advantage of using 80V is that the terminal contacts are "wetted" at each changeover and are thus, as intended, kept free of oil and other contamination from the mechanical parts of the terminal. The opto-isolation method can of course be changed for other voltages, simply by altering the value of the resistor in series with the l.e.d.

Fig. 21: The most common terminal output arrangement, a switch biased in the marked condition

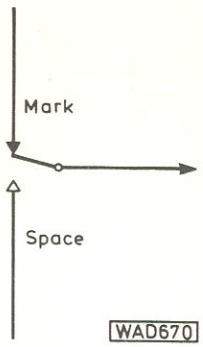


Fig. 22: An alternative form of terminal output, a flip-flop which also "de-bounces" the switch contact

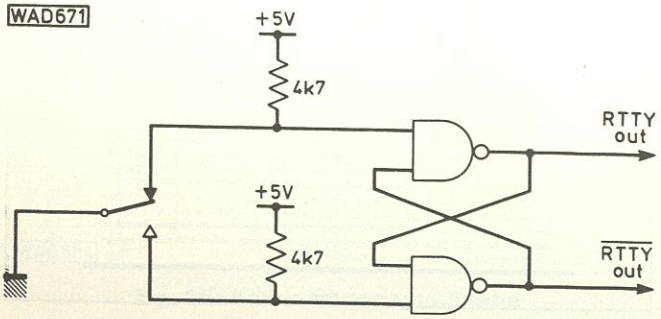
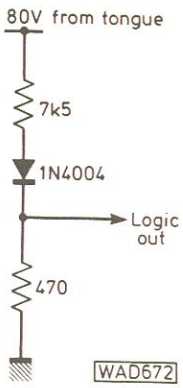


Fig. 23: The simplest method of converting 80 volt signals down to TTL levels, but not the safest. Consider, for instance, the result of the 470Ω resistor going open-circuit



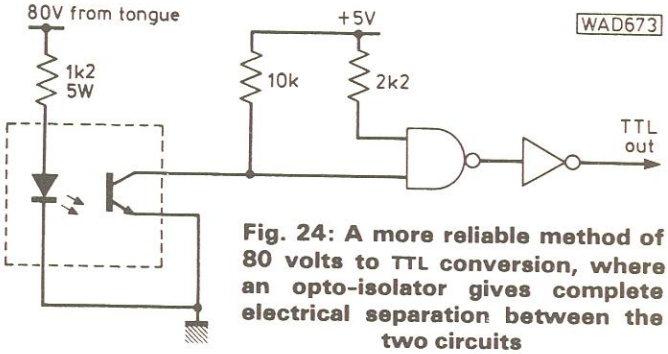


Fig. 24: A more reliable method of 80 volts to TTL conversion, where an opto-isolator gives complete electrical separation between the two circuits

Generating AFSK

Having developed a TTL-compatible signal as the output of the terminal (with 1 representing mark and 0 representing space), the next task is to produce an AFSK signal, with an output of 1445Hz for mark and 1275Hz for space. Four basic methods are available for the generation of AFSK signals: switching betwen two oscillators; switching the frequency-determining element of a single oscillator; variable division of a crystal-controlled oscillator and use of a special integrated circuit.

For the first method, almost any type of audio frequency oscillator can be used—f.e.t., multivibrator, 555 and so on. For example, two circuits based on Fig. 25 could be used with a suitable switching mechanism.

A reduced component count is one advantage of the second method—using a single oscillator with alternative frequency-determining components, rather than two distinct oscillators. Again, any number of different types of oscillator can be employed. *RTTY The Easy Way* uses a simple two-transistor multivibrator that the author used for many successful QSOs. This circuit is shown in Fig. 26. The pre-set potentiometers should be of the multi-turn variety. With a mark input, the 10kΩ pot is adjusted for 1445Hz output; then the 5kΩ pot is adjusted for 1275Hz output with a space input, the latter pot being switched in and out of circuit by the BC108 transistor.

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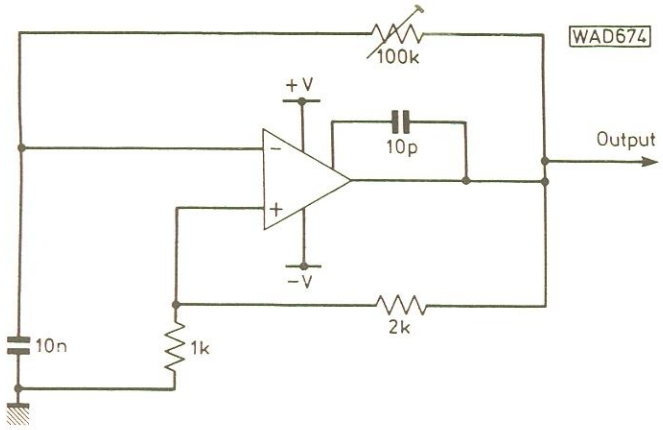


Fig. 25 ▲

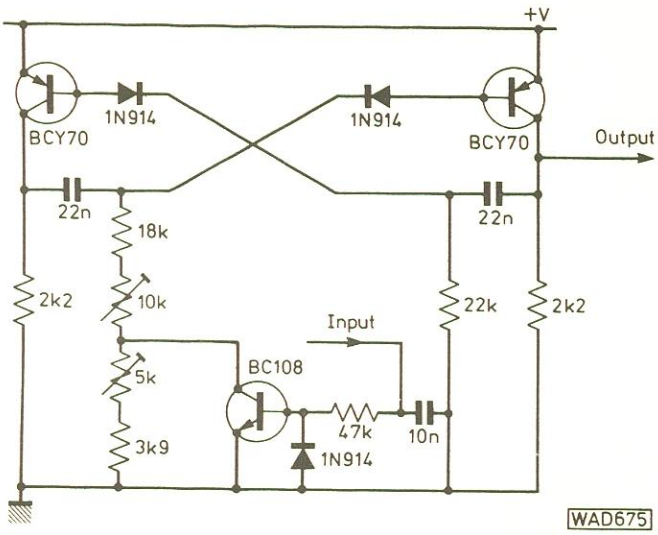


Fig. 26 ▶

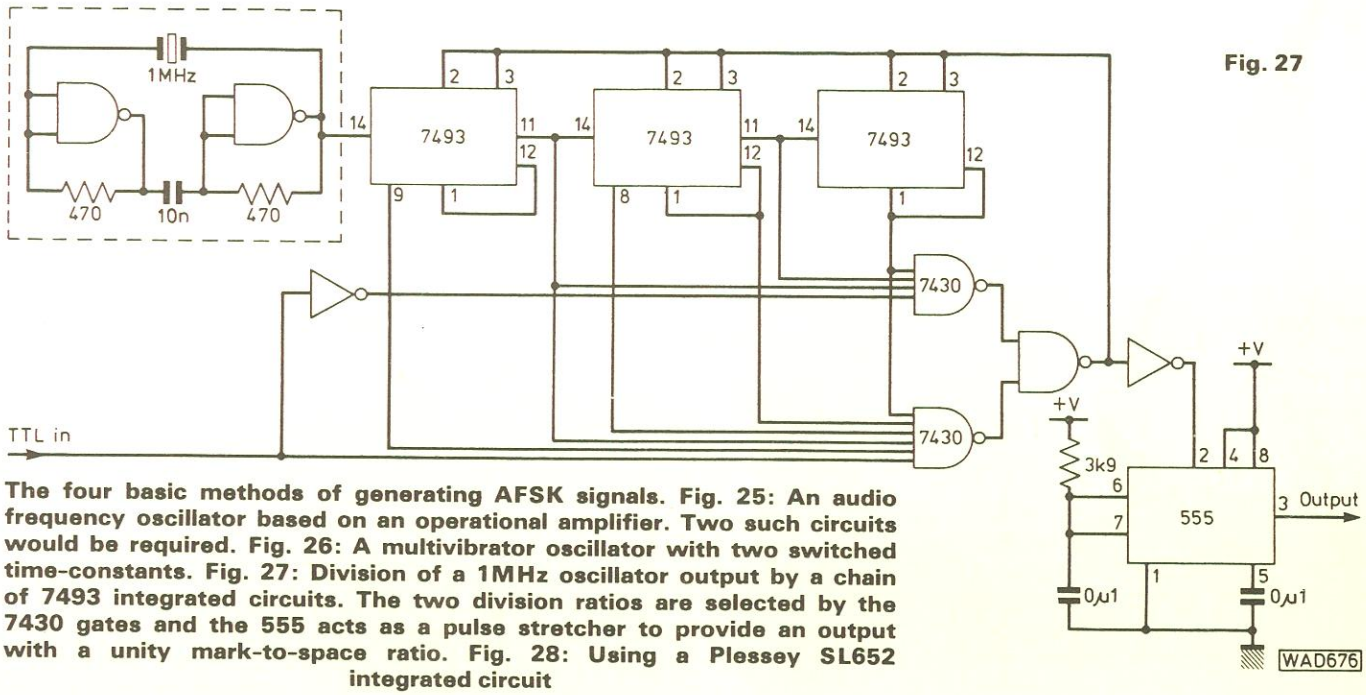


Fig. 27

The four basic methods of generating AFSK signals. Fig. 25: An audio frequency oscillator based on an operational amplifier. Two such circuits would be required. Fig. 26: A multivibrator oscillator with two switched time-constants. Fig. 27: Division of a 1MHz oscillator output by a chain of 7493 integrated circuits. The two division ratios are selected by the 7430 gates and the 555 acts as a pulse stretcher to provide an output with a unity mark-to-space ratio. Fig. 28: Using a Plessey SL652 integrated circuit

Generating AFSK tones by division of a crystal-controlled oscillator is a useful method, particularly if an accurate source of, say, 1MHz is already available from a counter, MPU or other test oscillator.

Division of 1MHz by 784 and 692 respectively will produce outputs of 1275Hz and 1445Hz, both within 1Hz of the desired frequency. This is easily done with 7493 dividers as shown in Fig. 27, which also shows an optional crystal-controlled oscillator. The 555 timer is used to lengthen the very short reset pulses from the gate, in order that the ouput waveform has an even mark-to-space ratio. Unused inputs of all the gates should be taken to the positive 5V rail via 2·2kΩ resistors. This circuit has the advantage that, given an accurate source of 1MHz pulses, the constructor can produce an AFSK unit that does not require any line-up procedure.

Several "custom" i.c.s can be used to produce AFSK with minimum external components. The author has experimented with the Plessey SL652, which may be used as a stable tone source as shown in Fig. 28. The 10kΩ preset

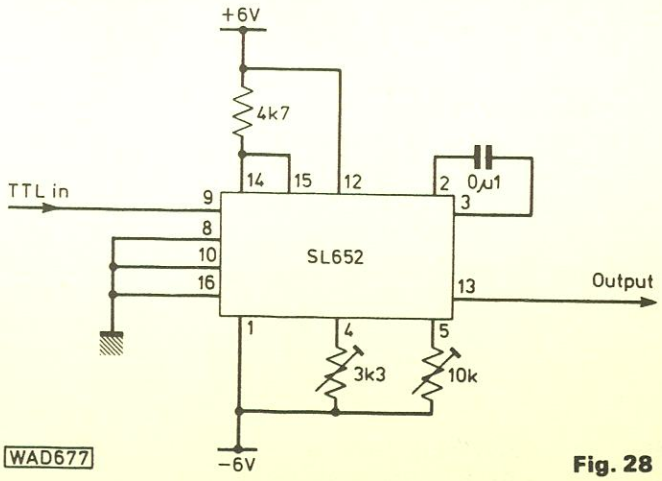


Fig. 28

(which should be multi-turn) sets the mark frequency (pin 9 high), after which the 3·3kΩ preset (also multi-turn) is used to set the space frequency (pin 9 low). For a minimum-chip terminal unit for transmission and reception the reader is referred to *Radio Communication Handbook* by Plessey Semiconductors, which suggests a method by which a single SL652 may be used for both functions. If experimenting with the SL652, great care must be taken not to exceed 6 volts on either power rail. Op. amps., for an active filter say, can be run from ±6V in conjunction with an SL652.

Each of the AFSK circuits described above produces a squarewave output. This should not be fed directly to a transmitter but should first be passed through a low-pass filter. A simple CR network such as shown in Fig. 29 will suffice, although the user may care to add an active band-pass filter based on a 741 if desired.

Storing Messages

Using a combination of circuits discussed so far, the licensed amateur can very easily join the ranks of active RTTY enthusiasts, assuming of course he has some form of terminal. However, with the exception of microprocessor owners (dealt with in a later article), it will soon become evident that some additional equipment is highly desirable. This is because of the difficulty of sending repetitive messages from a keyboard—particularly for the one-finger typist. The most obvious message that needs to be sent repeatedly is CQ, although even this has variants

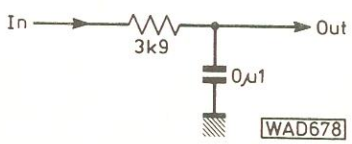


Fig. 29: A simple CR low-pass filter to limit the AFSK generator output spectrum

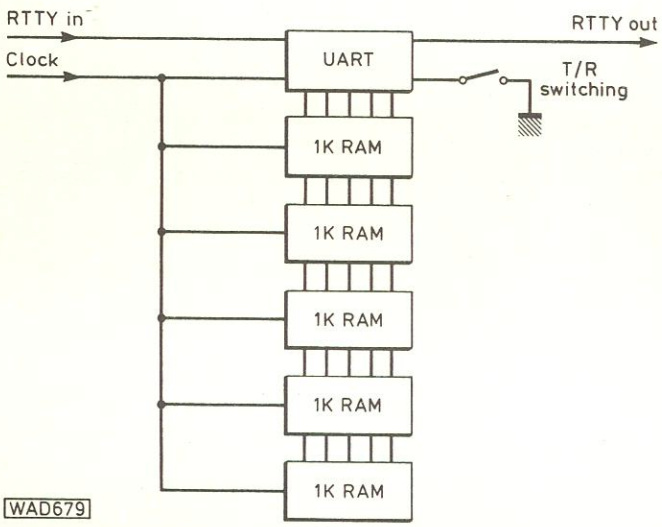


Fig. 30: Basic block diagram of a 1K RTTY store

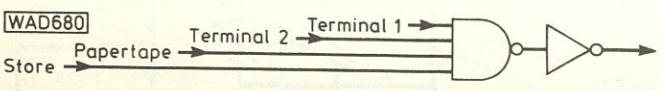
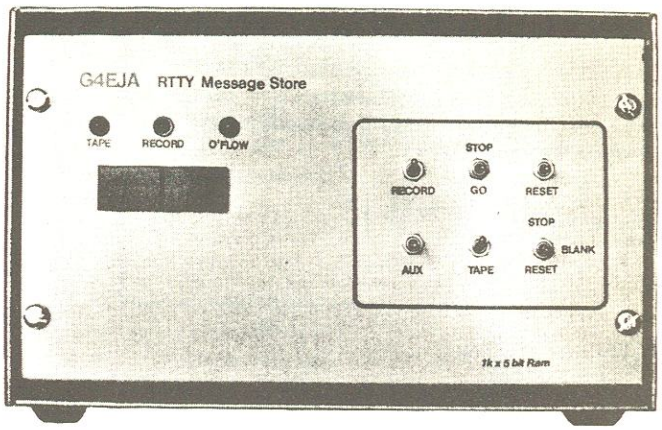


Fig. 31: Combining several message-originating devices onto a single TTL bus



The control panel of the author's 1K RTTY message store

(CQ DX, CQ CONTEST, etc.). Other messages can include test patterns, one's own callsign (particularly when beset by QRM) and RTTY pictures.

Incidentally the two most common test patterns are the "fox" message (the quick brown fox jumped over the lazy dog in the stable), because it includes every letter of the alphabet, and a string of RYs because this is the resulting output when keying alternate mark/space.

Traditionally the source of such standard messages has been paper tape. Many of the older TTY terminals include a paper-tape reader and punch, and stand-alone units are still readily available if rather cumbersome. Messages on tape can be made into continuous loops and sent as required. For example, a tape might contain:

CQ CQ CQ CQ DE G4EJA G4EJA

followed by a carriage return and line feed. This can be formed into a loop and sent about ten times as a means of initially establishing a contact.

A favourite tape-loop subject is a description of one's particular station, which would normally be sent during each QSO. Many terminals have an auxiliary contact that is made or closed when figure J (or bell) code is received. This can be used to stop the paper tape reader when, for example, some variable information has to be inserted into the transmission (such as a contest report and number).

Two electronic alternatives to paper tape are available (excluding microprocessors). These are the diode matrix and RAM (Random Access Memory). The former is not really a good idea for anyone starting from scratch because it is cumbersome to set up, difficult to change, and no cheaper now than using some form of semiconductor storage.

An RTTY message can be started in RAM such as the 2102. If five 1K chips are used then 1K RTTY characters can be stored. A UART (Universal Asynchronous Receiver Transmitter) is used to convert from serial RTTY to the parallel mode needed to load the RAM. A block diagram of such a system is shown in Fig. 30, where the necessary clock—at 16 times the baud rate—can be derived by further division if a crystal-controlled AFSK generator is used. A detailed circuit description is beyond the scope of this article; interested readers are referred to a design by G3PLX in the *BARTG Newsletter*, December 1977.

Remembering that any RTTY device is in the mark condition when idle, it is easy to see how a number of message-originating devices can be paralleled onto a single TTL bus (Fig. 31).

Reprinted from Practical Wireless

introducing RTTY part 4

Jeff MAYNARD G4EJA

It is not necessary to build a terminal unit to join the ranks of RTTY enthusiasts, since commercial units are available. The intending purchaser can opt for a straight terminal unit, using the type of modulation and demodulation techniques discussed in earlier parts of this series, or a complete RTTY system.

Catronics

The first piece of equipment to be described is the Catronics CT103 receive and transmit RTTY terminal unit which was available until recently. Unfortunately the makers are no longer in business but as there will be many of these units around this review has been left in this reprint. The two models which were available, the CT101 and CT103 differ only in as much as the CT103 has an 80V magnet driving interface as well as a TTL interface.

Powered by an in-built mains power supply unit, the CT103 has four DIN sockets on the rear panel for the various connections. These include both types of 5-pin arrangement, to reduce the risk of damage. The receiver input is protected by the simple but effective back-to-back diode technique (Fig. 32). Requiring only 10mV and with an input impedance of 4·7kΩ the CT103 can be connected to the extension speaker or headphone socket of any receiver without imposing any significant loading. More than sufficient drive is provided with the station receiver set for a normal listening level. There are no adjustments for this input.

The AFSK output is driven from a source impedance of some 2kΩ and is adjustable via a 47kΩ on-board preset potentiometer which must be adjusted to give the correct drive or modulation depth for the transmitter in use. Over-driving the transmitter could, of course, introduce "flat-topping" and subsequent distortion. A further pin of this particular DIN socket provides AFSK prior to the preset. This can be fed to a domestic tape recorder for simple message storage. For playback the recorder output is directed to the unit input in lieu of the receiver output.

A TTL-compatible output of demodulated RTTY is available for feeding a VDU (such as the G3PLX design) or a microprocessor. The same socket will also accept TTL-compatible input (from keyboard or MPU or whatever) for conversion to AFSK. This input is not protected, so the user must be most careful not to allow a voltage outside the TTL range 0–5V to be applied. The input is however internally pulled to 5V via a 4·7kΩ resistor, so the input can be left floating or even connected to a tri-state bus without problem.

The CT103 provides for a polar input (see Fig. 22, Part 3) that requires a grounded centre contact and two other contacts giving a ground for mark and space respectively. A flip-flop is used to debounce this input, which is buffered from the TTL gates by small-signal transistors which are themselves protected by current-limiting resistors and Zener diodes.

The final socket provides the magnet driving output (supplied as an optional extra), which can be selected by an internal switch for single or double current. Whichever type of magnet drive is required, the user needs to set the magnet current. This is done empirically with a milliameter temporarily replacing the on-board fuse whilst various switch combinations are tried. The AFSK output level and the magnet drive current limit are the only internal adjustments necessary.

The unit is quite simple to use once the user has accustomed himself to the tuning aids. These consist of two l.e.d.s. The first of these—the "Signal" indicator—will be on steadily when both mark and space tones are within the input passband; the signal l.e.d. flashing indicates mark or

Fig. 32: The input limiter arrangement on the CT103

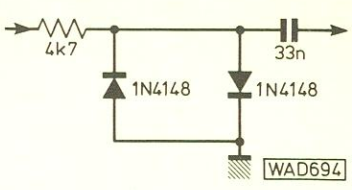
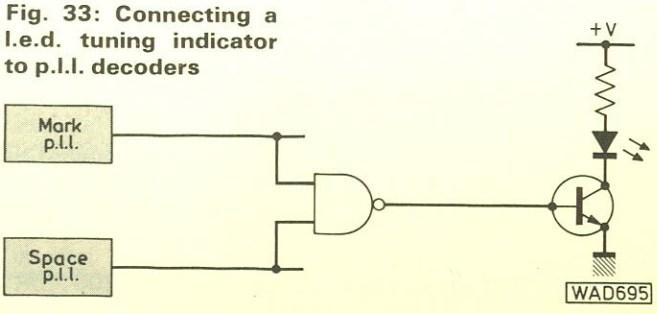


Fig. 33: Connecting a l.e.d. tuning indicator to p.l.l. decoders



space tone (but not both). An incoming signal is correctly tuned when the signal l.e.d. remains on. The second l.e.d.—labelled "Mark"—is on for high tone (usually mark) and off for space (low tone) and so will flash in normal operation.

Some form of tuning indicator is normally desirable on a demodulator to indicate when a mark and/or a space tone is being received. This is easiest to accomplish with p.l.l. decoders which can have a l.e.d. across the output as shown in Fig. 33. An *LC* type demodulator can be modified to drive a milliameter to indicate relative signal strength as shown in Fig. 34.

By far the best form of tuning indicator is the "cross-pattern indicator" using a simple form of oscilloscope. In use a correctly tuned RTTY signal will show a cross with equal length arms. A voltage representing the mark signal is fed to the horizontal oscilloscope amplifier, and that representing the space signal to the vertical amplifier. An incorrectly tuned RTTY signal will show as a cross whose horizontal arm is longer than its vertical arm, or vice-versa. An interface to a standard oscilloscope can be built but the required circuitry is so simple that a stand-alone indicator can be built using a surplus oscilloscope tube such as a 3BP1 as shown in Fig. 35. The 88mH coils are tuned to resonance (one each for mark and space) by careful selection of their parallel capacitors. The coils also provide step-up from an 8 ohm speaker connection.

The two inputs to the CT103 (TTL and polar) are bussed via diodes, and so two devices (such as keyboard and a solid-state message store) can be permanently connected provided each restores to mark when not in use. Also connected to the same bus is the output of the demodulator. This means that any output from a terminal is echoed back on transmission and a machine with local copy will print each character twice. This can be overcome by operating the button designed to stop printing and which forces the output of the demodulator to mark. An extra pair of contacts on this button was used by the author to ground the p.t.t. line of the transmitter feed, and so act as a transmit/receive control. Control keys are also provided for normal/reverse signal switching and wide/narrow shift selection.

Claimed to be a "unique digitally controlled circuit" is Autoprint, fitted to the CT103 in place of antispace and autostart features. The Autoprint works like this—from the steady-state mark position an RTTY signal of at least one second duration must be received for the output to be turned on; following this the output remains on as long as RTTY is not lost for more than 250 milliseconds (control set to fast) or 1 second (control set to slow). If the incoming RTTY signal is dropped for a period exceeding this time, the system is reverted to mark and the Autoprint is reset.

The Autoprint circuitry is accomplished with a pair of 555 timers. In practice it works well to prevent a terminal chattering when tuning across a band. But, as the manual suggests, it is necessary to switch Autoprint off when trying to copy weak signals.

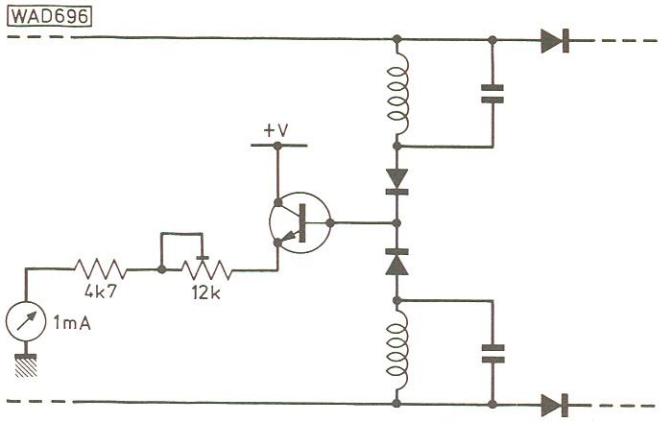


Fig. 34: Attaching a signal strength meter to an *LC*-type demodulator

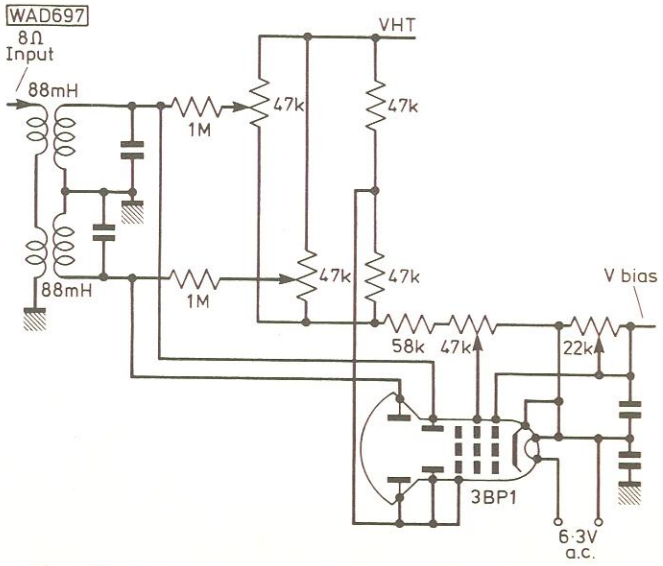


Fig. 35: A simple stand-alone tuning oscilloscope

Hal

Ready-built RTTY terminal units are also available, via Radio Shack, from Hal Communications Corporation of USA. These include the ST-6000 with a range of facilities including a tuning oscilloscope at £414 and the ST-5000 at £230. Unfortunately no Hal equipment was available for evaluation.

Hal are perhaps best known for their RTTY terminals which now include three models all based on integral keyboard/VDU units. Top of the line is the DS3100 ASR (or BSR—Buffered Send Receive—as Hal like to call it) again available through Radio Shack at £1536. The DS3100 provides for ASCII and Morse as well as RTTY, and the operational features outlined below are available for all three modes. Speeds available are as follows:

ASCII—110 to 9600 bits per second
Morse—1 to 199 words per minute
RTTY—45 to 100 baud

The RTTY interface is a current loop requiring 18–120mA at voltages up to 200; output is polar. Incoming RTTY traffic is buffered and any 12- or 24-line segment of the 150-line buffer capacity can be displayed at 72 characters per line (green phosphor 12in diagonal screen). Received (and transmitted) data is also available at 300 b.p.s. in ASCII at an RS232 interface.

The DS3100 really comes into its own when transmitting. Text can be precomposed into the buffer during reception if required; otherwise transmission is from the keyboard, either as typed, in complete lines or in complete words. Spaces caused by use of say the line mode are automatically filled with downshift (letters) characters. Line transmission, identified by bursts of full-speed text in-

terspaced with idles or shift characters, can be useful for the transmitting station but is annoying—to the author's mind—for the receiving station. It should only be adopted by the worst of typists!

Ten different 32-character messages can be pre-programmed and inserted into the transmit text as required. Such messages may be chained to produce longer messages. A similar feature issued by the author to store four messages:

CQ CQ CQ CQ CQ
CQ DX CQ DX CQ
CQ TEST CQ TEST
DE G4EJA G4EJA G4EJA (CR/LF)

the appropriate combination being selected by one or two key depressions. Two of the ten messages are stored in non-volatile ROM, and one of these can be sent in Morse regardless of selected terminal code.

The DS3100 responds to the WRU character by activating an auxiliary contact and sending its number one pre-programmed message. This can be used to activate, say, a tape recorder or an external alarm in a net. Three other external circuits may be activated by keyboard or character control, and a keyboard switch is available for transmit/receive switching. (This feature is most useful and is worth building into any RTTY system—it is important to be able to call immediately the other station reverts to receive, particularly when working DX. The author's system requires only one key to be pressed to mute the demodulator, switch the rig to transmit, turn on the heatsink fan and take the terminal from local—for pre-compilation—to on-line.) The time of day and date are available for insertion into transmitted text from a single key. Automatic downshift on space, on-screen status indicators and pre-programmed test messages coupled with two-level screen intensity combine to make operating the DS3100 a simple task.

Other Sources

Other RTTY equipment is sometimes advertised by B. Brookes-Electronics and by Joerg Klingenfuss. The best source of such further information is the newsletter of the BARTG (British Amateur Radio Teleprinter Group). Published four times per year the newsletter is excellent value for the £2 annual subscription. In addition to the newsletter, BARTG organise an annual RTTY convention, broadcast RTTY news bulletins (via GB2ATG), appear at the major rallies, advise on technical matters and maintain a register of "difficult to obtain" spares. Further information in exchange for a stamped addressed envelope from the membership officer:

J. Beedie G6MOK
161 Tudor Road
Hayes
Middlesex UB3 2QG
Tel: 01-561 0010

Any reader even slightly interested in RTTY is strongly recommended to join BARTG.

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introducing RTTY part 5

Jeff MAYNARD G4EJA

The microprocessor has brought quite a revolution to RTTY. The equipment from Hal outlined in the previous part of this series is only possible because of the microprocessor. Also possible is the use of an existing microprocessor-based system for RTTY purposes. So the Pet or Apple, or home-brew system, can be used to decode and display or originate RTTY. The advantages are numerous and include domestic acceptability (how many XYLs appreciate a Creed 7B thumping away in the attic?), availability and versatility. It is the latter that this article will concentrate upon.

Reception

First, the reception of RTTY by home computer. Before a program can start to examine any potential RTTY signals, it is necessary to convert the incoming tones into a suitable (i.e., TTL-compatible) signal. This is easiest to achieve with a p.l.l. as shown in Fig. 36 (Part 2 of this series should be consulted for a full description of p.l.l. demodulators and alignment details for the circuit shown).

With this interface the user can feed TTL-level Baudot code (plus noise, QRM, c.w.), etc., to an auxiliary input port. It is possible of course, to convert the Baudot to parallel form via a UART (universal asynchronous receiver transmitter) and change from a serial- to a parallel-type interface. However, use of a serial interface avoids the need for additional hardware and allows the conversion, when necessary, to be done by software.

In the no-signal condition the RTTY input sits at mark (TTL level high or 1). A new character is always signified by a change from mark-to-space (high to low) for 22 milliseconds. This is of course followed by further mark/space transitions but we can return to these later.

The simplest way to identify RTTY by software is as follows: The program will wait until a mark-to-space transition first occurs; if this space is still present 11ms later it can be taken as a mark. The signal is then examined at 22ms intervals *from this mid-point*—i.e., in the middle of each expected element—and a mark or a space registered. Following the fifth data bit, the signal should revert to mark for at least 33ms (1½ stop bits). This procedure is shown in the flow diagram of Fig. 37. The output of this routine is a 5-bit representation of each incoming Baudot character. For example, the letter A would be 11000 where 1 is a mark and 0 a space. It is possible to be more selective in the acceptance of incoming RTTY by sampling the character elements more often. For example each element could be examined, say, seven times—every 3 milliseconds—and a decision made as to whether it was a mark or a space by majority. This technique can eliminate

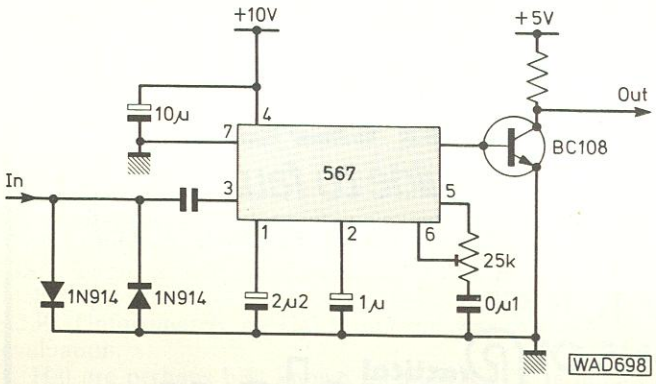


Fig. 36: A TTL interface for the home computer

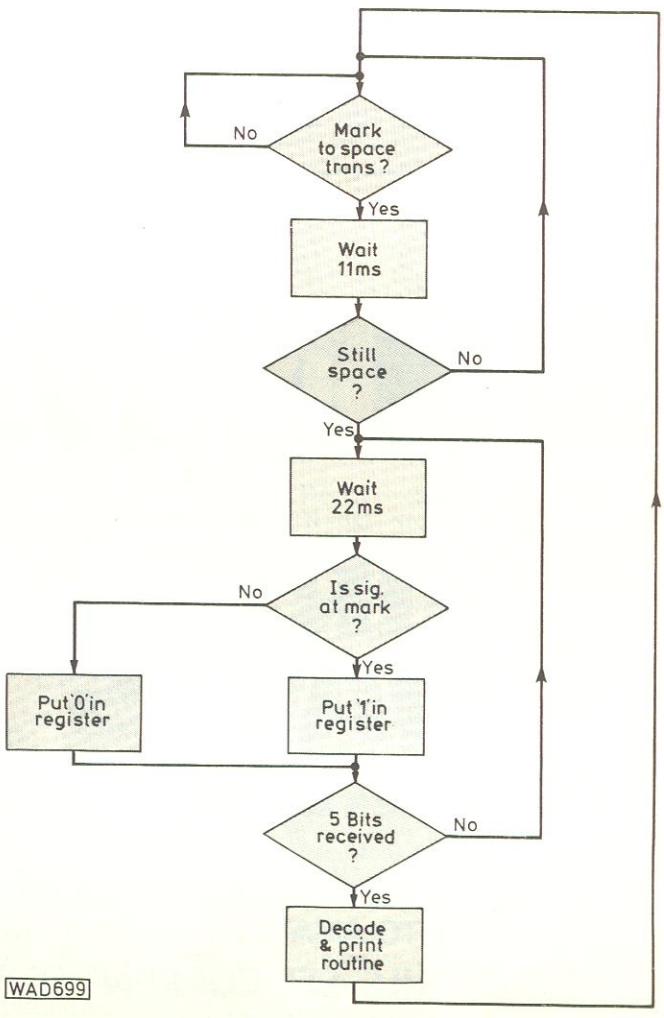
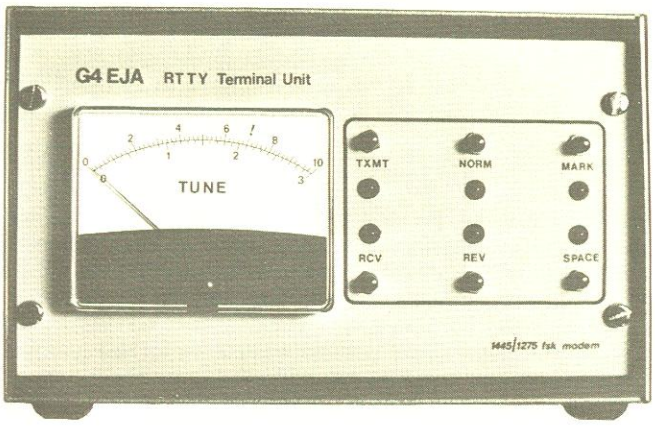


Fig. 37: RTTY to Binary conversion flow diagram

Reprinted from Practical Wireless, January 1981



The Terminal Unit of the author's RTTY equipment

some of the problems of short noise bursts that coincide with a sampling point. Some scope for experimentation in respect of sampling frequency is clearly available.

Whichever method is adopted, the next problem is to fill in the box labelled "decode and print routine". The binary pattern (shown overleaf) is a representation of a Baudot character and as such is not directly compatible with an ASCII-based computer. To convert from Baudot to ASCII is quite simple—the Baudot code can be taken as a binary value. For example the letter T is 00001, carriage return is 00010, the letter O is 00011 and so on. Thus if the Baudot code is used as an offset to a table arranged in order of binary value, the appropriate character can be extracted directly. As another example consider the letter L, which having the code 01001 or binary 9 would have the ninth place in the table or list. Baudot codes of course represent two different characters depending on the shift being letter (lower) or figures (upper)—see Part 1. The look-up routine must take account of this by keeping a shift flag and referring to the appropriate table.

There are a number of refinements that can be inserted into a program between the decoding—as outlined above—and the printing or display of the characters. Some of these are discussed below.

Some home computers—such as the Pet—have a screen width less than that normally found on an RTTY machine. It is necessary therefore to insert carriage returns at appropriate places, taking care of course not to split a word.

To overcome the effects of QRM, it is often helpful to force the output to letter shift each time a space character is encountered. The program should include the facility to change shift from the keyboard whilst decoding is taking place.

Logging by program can be done by searching for key words such as "your call sign" DE . . . but more of this later when discussing transmitting by software. The s.w.l. can finish at this point, being unconcerned with the problems of transmitting, and can concentrate on finding the DX. There are a number of awards available for RTTY including those from BARTG, SARTG (Scandinavia), CARTG (Canadian), DARC (German) and *RTTY* magazine. A number of other awards—available to listeners and licensed stations—can be endorsed for RTTY. In this category is the Cheshire Award, administered by the author, for which no RTTY claims have yet been made.

Transmission

To transmit RTTY from a home computer requires first a reversal of the reception procedure. Individual ASCII characters must be converted to Baudot—the simplest method is to use the ASCII absolute value as the offset for a table look-up. The Baudot can be transmitted by switching an auxiliary output off for 22ms for each required space, remembering to leave mark for at least 33ms after the last bit and to precede the bits with a 22ms space. Suitable TTL to AFSK converters to drive the station transmitter have been described earlier in this series.

Note that the Baudot character is extracted bit by bit from the micro word by ANDing with 0000 0001 and then shifting right one bit (assuming that the Baudot representation has the signal bit 1 to the right). Incidentally, readers having difficulty following the programming techniques described might like to read the author's *Computer Programming Made Simple*, published in London by W. H. Allen and recently extensively revised to encompass the latest techniques and technology.

Transcribing from ASCII to Baudot and then to TTL is the simplest of the transmitting options. The greatest scope is in data and message manipulation—the limit being set only by the user's imagination (and perhaps system memory capacity!). Baudot uses figure- and letter-shift characters to assign alternate meanings to codes. Since this is not the case in ASCII, the user's RTTY program will need to insert shift characters as appropriate. A sequence such as shown in Fig. 38 will prove adequate. Many RTTY users find it useful to send a down shift (letter shift) each time a space is encountered.

Letter- or down-shift characters can also be sent during idle periods. For example a program could detect the fact that a key has not been depressed for, say, two seconds and start to send shifts. If text is being sent line by line—i.e., text output only commenced when a carriage return is keyed—the program can automatically send down shifts (this is known as "diddling").

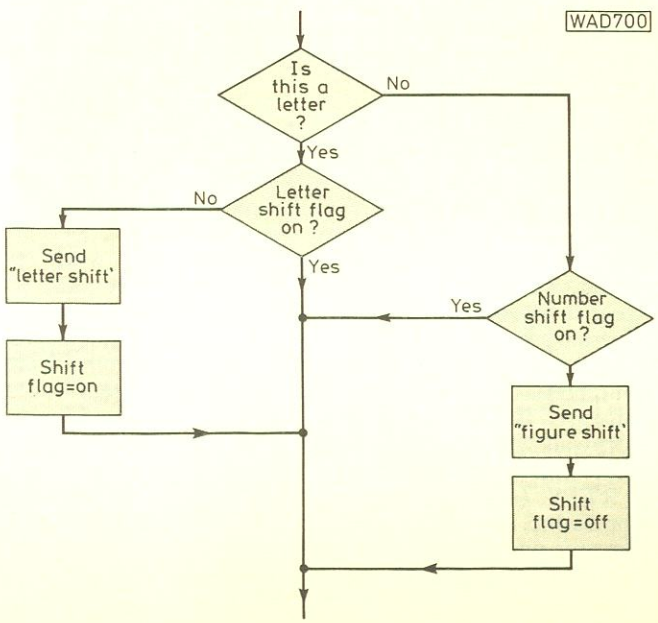


Fig. 38: A flow diagram for shift characters

A single ASCII code will indicate carriage return and line feed (CR/LF) but in Baudot these must be sent separately. It is useful—to the mechanical-based receiving station—if two carriage returns are sent; the inclusion of a down shift is another good idea. Thus, when the user presses "return" on his ASCII keyboard the Baudot sequence:

CR CR LF Let

should be generated.

Generating "standard" messages from a single key is—from the author's own experience—one of the most useful features of a software-controlled RTTY station. A character with no Baudot equivalent—such as $—can be selected to initiate standard messages. Thus the user could introduce ten such messages, for example:

$0 CQ CQ CQ CQ
$1 CQ TEST CQ TEST
$2 CQ DX CQ DX CQ
$3 RYRYRYRYRYRY
$4 THE QUICK BROWN FOX . . .
$5 DE G4EJA G4EJA
$6 IN WIDNES CHESHIRE UK
$7 YOUR REPORT IS RST
$8 PSE QSL VIA BUREAU
$9 DD/MM/YY OO:OO GMT

In the case of $9, the program would of course insert the current date and the time of day. Clearly the user can extend this principle to a comprehensive range of messages including a station description (a popular RTTY topic). Again the limiting factor is imagination and memory capacity. The recording of time and date will be useful for log keeping if a hard copy is available. This is particularly the case in a contest where, to obtain maximum points, the operator must spend a minimum amount of time on clerical work whilst the contest is running. A word of caution though for those without hard copy. If log keeping information is held by software for later entry into the station log, the user must make provision for retrieving the information in case of mains or program (or any other) failure. Regular dumps to disc or cassette should be made just in case.

Reversing the mark/space tones (by inverting the TTL output) and changing the baud rate are two other useful add-ons to an RTTY program. Such is the importance of these parameters that a program-activated alarm (for a second or two) should accompany them.

Buying Software

If the inexperienced programmer finds the work required to achieve the above a little daunting (the more so because assembler language will be required to achieve the necessary processing speed) there is no cause for alarm. Ready-made systems are available for most popular home computers. A supplier of one range of amateur radio software is Nicomtech of Stephens Road, Saltash, Cornwall who has systems for TRS-80, Exidy Sorcerer, Apple and Pet hardware.

RTTY (and Morse) systems (produced by Macrotronics Inc. of California) are available for TRS-80, Exidy Sorcerer and Pet at £96.60, £96.60 and £67 respectively. These prices include a simple (phase-locked loop-based) terminal unit together with the necessary hardware interface for the computer system in question. The manual does point out that, in marginal reception conditions, a better t.u. will be desirable. Output from the terminal unit is polar or +12 volts. Output for transmission is via a transistor (together with sidetone for Morse) which can be used to directly key a c.w. transmitter. For RTTY, however, an AFSK unit will have to be built. Any of the designs described earlier in this series will be suitable.

A package for Apple II users is also available from Nicomtech at £17.82. This provides only the necessary software and the user must construct a terminal unit and the necessary interface circuitry (diagram supplied with the software). From the same source are Apple SSTV programs and satellite prediction and logging for the Pet.

Copying RTTY QSOs on a video is just like reading the c.w. or phone parts of the band as regards format and terminology and so on. Stations will usually be found calling CQ on 20 metres (around 14·090MHz), and a typical RTTY QSO might go like this (author's transmissions underlined):

CQ CQ CQ CQ DE W1ABC
CQ CQ CQ CQ DE W1ABC
CQ CQ CQ CQ DE W1ABC
PSE KKK
W1ABC DE G4EJA G4EJA G4EJA
W1ABC DE G4EJA IN WIDNES
PSE K
G4EJA DE W1ABC
OK OM TNX FOR THE CALL
UR RST HERE IS 579 579 579
NAME IS BOB AND QTH IS NY
SO HOW COPY??
G4EJA DE W1ABC PSE K
W1ABC DE G4EJA
OK BOB, ALL 100% HERE
UR SIG IS FB AT RST 599 599
NAME IS JEFF AND QTH IS WIDNES
RIG IS ATLAS 210 AND 2 ELE TRIBANDER
AT 40 FT. TU IS HOME BREW TO VDU
WITH 8K RAM
W1ABC DE G4EJA KKK
G4EJA DE W1ABC
OK, JEFF ALL COPY GOOD SIG FROM YOUR
ATLAS. RIG HERE IS TR7 FEEDING
3 ELE MONOBANDER AT 60 FT. RTTY IS
DS-3000 FROM HAL.
WX TODAY IS SUNNY AND WARM
THANKS FOR QSO AND QSL IS OK VIA
THE BURO. 73'S FOR NOW JEFF AND
CUAGN. G4EJA DE W1ABC AR SK
W1ABC DE G4EJA OK BOB, WX HERE
NOT SO GOOD. QSL IS OK AND WILL LOOK
FOR YOU IN THE CONTEST NEXT WEEK
73 73 73 DE G4EJA
BI BI

The final line would probably also contain a couple of bell characters. Contest QSOs are similar to those in other modes with the emphasis being on speed of course, although the exchange of information is very important. "Rag-chewing" is also popular on RTTY; the author has been known to chat to a state-side RTTY station for almost two hours, and has a regular sked with a Swedish club station.

RTTY has its adherents, as do the various other facets of amateur radio, and it is for the individual to decide whether RTTY is the mode to follow. The shortage of RTTY in some countries can give a new twist to DX; the author recently worked a station in OX (Greenland) only to be told that he was one of only two RTTY stations currently active in that country! ●

Reprinted from Practical Wireless

RTTY with the ZX81

by Dick Ganderton G8VFH

Part 1

With the minimum of additional components and a suitable machine code program the 16K ZX81, and the ZX Spectrum, can be used to receive and transmit RTTY signals. The main considerations taken into account when designing this project were that it should be easy to build and set-up with no difficulty in obtaining components and that the cost should be kept to a minimum.

The project is split into two parts—the first dealing with the construction of a simple yet effective terminal unit with the second part covering the construction of the necessary interface board, the software and some hints on reducing the interference created by the computer itself.

Essential Basics

To receive or transmit RTTY using a computer the system shown in block form in Fig. 1.1 is required. The receiver audio output—in the form of RTTY five-element, two-tone coded signals, is fed into a unit which converts the two tones (Mark and Space) into corresponding TTL logic levels.

This string of logic levels is then converted by the interface into a form which the ZX81 can understand and process. The ZX81 is used to perform the decoding of the signals and this it does by comparing the signals with a look-up table contained in the program and deciding whether a valid RTTY character is present or not. If it has detected a valid character this is printed on the screen and the next set of five-elements operated on.

In transmit mode the ZX81 generates the five-element codes corresponding to the characters to be transmitted and the interface converts these into a serial form ready for feeding into the audio frequency shift keying (a.f.s.k.) generator. This circuit produces the two audio tones corresponding to Mark and Space depending on whether the interface has output a logic *0* or logic *1*. The output of the a.f.s.k. generator is then fed into the microphone socket of the transmitter.

> The only unusual components used in this project are the multiturn top-adjust cermet preset potentiometers. The p.c.b. is designed to accept RS Components 186–514 types.

The circuit of the terminal unit is shown in Fig. 1.2 and can be broken down into three areas. The receive chain is made up of IC1,2,3,4 together with their associated components.

The input—in the form of Mark and Space tones (1445Hz and 1275Hz respectively)—is processed by a 741 op. amp. (IC1) to provide a high level drive for the two phase locked loop i.c.s. Diodes D1,2,3 and 4 provide input protection for the 741 and 567 i.c.s.

Both the p.l.l. chips are driven with high level inputs to ensure that their bandwidths are constant and do not vary with changing input levels. This is important to obtain consistent results. IC3 has its bandwidth set by C11 and its centre frequency can be adjusted by R14 to 1445Hz. The second 567 p.l.l. i.c. (IC2) has its centre frequency set to 1275Hz.

The output level of a 567 changes from logic *1* (+5V) with no signal input to logic *0* (0V) when an input within its bandwidth is present.

As only a Mark or Space frequency (but not both) should be present at the inputs of the p.l.l.s one output has to be inverted before being combined by a NAND gate (IC4d). Tr2 performs this inversion. By using two NAND gates (IC4 contains four 2-input NAND gates) it is very simple to obtain a NORMAL or REVERSE sense t.t.l. output ready to be input into the interface board. Switch S2 provides this facility by selecting either the output from the first NAND gate or the output from the second NAND gate (IC4c) which is wired as an inverter.

With the two p.l.l. chips tuned for 1445Hz and 1275Hz, only signals with shifts of 170Hz can be processed. Other shifts can be catered for by switching one p.l.l. out of circuit and S1 does this, simultaneously connecting the first NAND gate (IC4d) as an inverter. In this configuration only the Mark signal is operated on and the receiver is offset to tune the Mark frequency to 1445Hz. If you want to save the last penny, IC2 and its associated components together with S1 can be omitted from the p.c.b.

The a.f.s.k. generator is another p.l.l. chip, this time a 566 type used to generate a stable audio tone. Since two tones are required some means of changing the frequency generated is needed and this is performed by Tr1, effectively shorting out R19—one of the two preset potentiometers used to set the output frequency of the p.l.l. The

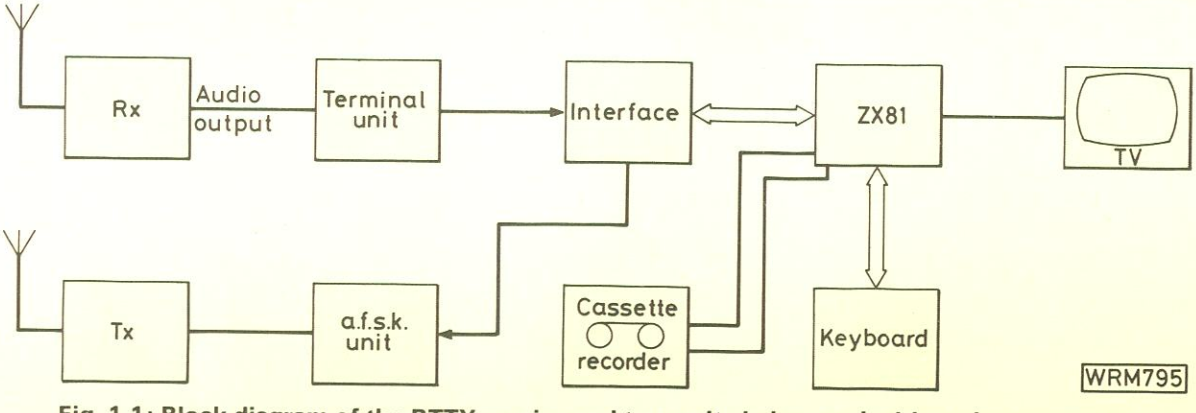


Fig. 1.1: Block diagram of the RTTY receive and transmit chains used with a microcomputer

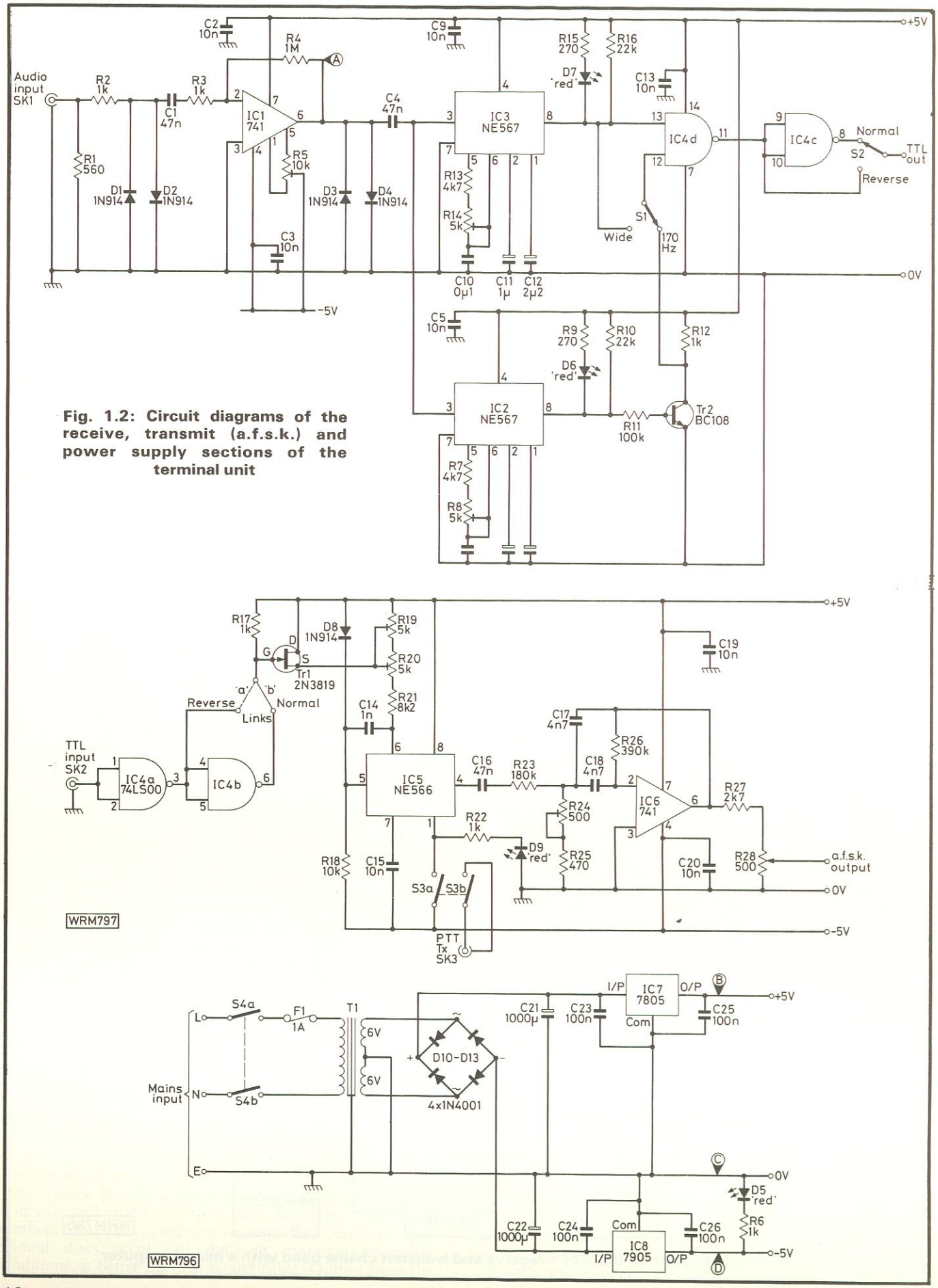


Fig. 1.2: Circuit diagrams of the receive, transmit (a.f.s.k.) and power supply sections of the terminal unit

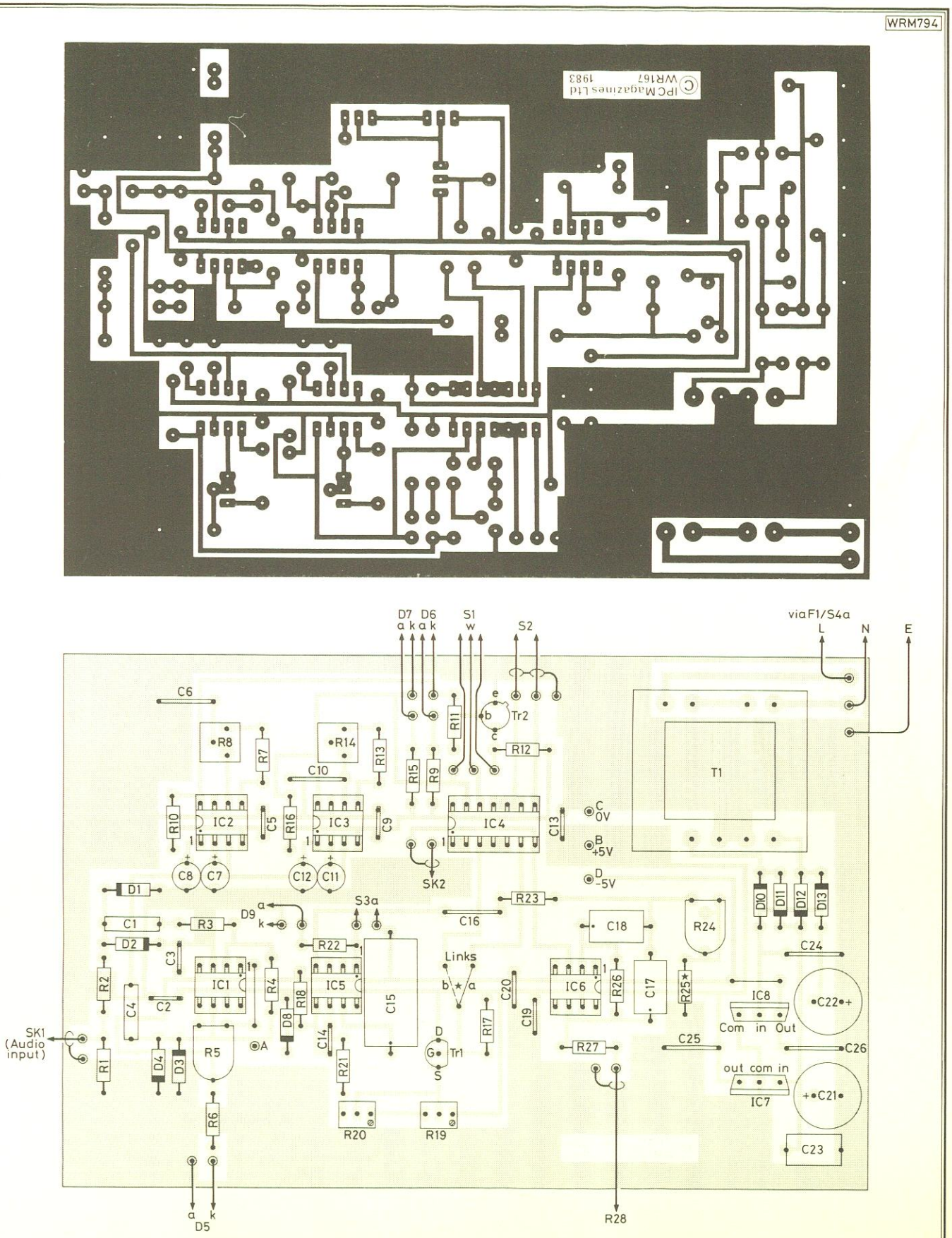


Fig. 1.3: The full-size copper track pattern for the p.c.b. together with the component placement drawing

RTTY with the ZX81

gate of Tr1 is either at logic *1* or *0* dependent on the output state of the NAND gate IC4b. By taking the gate to the output of IC4a instead the a.f.s.k. output sense can be reversed and this is done by changing over the link on the p.c.b. since this is not normally changed once set-up.

The 566 p.l.l. has two outputs, a square wave and triangular wave, and the latter is used here to feed an active filter built around a 741 op. amp. (IC6). Preset potentiometer R24 is used to set the bandwidth of the filter to give equal output levels of the Mark and Space tones at the wiper of R28.

During receive S3a switches IC5 off so preventing any possibility of stray pick-up affecting the receive side of the unit. D9 indicates that S3 is switched to TRANSMIT, while S3b operates the p.t.t. of the transmitter.

Power requirements are simple and only ±5V stabilised are needed. The p.s.u. is conventional with IC7 and 8 as stabilisers capable of providing ±5V at up to 120mA if needed. The mains transformer is mounted on the p.c.b. For driving a tuning unit such as the popular Toni-Tuna described in *Radio Communications* August 1982 stabilised supply rails can be taken from TPB, C and D.

Construction

All components with the exception of the l.e.d.s, switches and a.f.s.k. pot are mounted on the p.c.b. making construction simple. It should be noted that R19 and 20 must be multi-turn preset potentiometers otherwise it will be impossible to set-up the tones accurately. Also R8 and 14 must be good quality cermet types and preferably multi-turn as well although this is not so vital as with the a.f.s.k. generator pots. The p.c.b. accommodates both.

Internal wiring between the p.c.b. and the various

★ components

Resistors

Carbon Film ¼W 5%

270Ω	2	R9, 15
470Ω	1	R25
560Ω	1	R1
1kΩ	6	R2, 3, 6, 12, 17, 22
2·7kΩ	1	R27
4·7kΩ	2	R7, 13
8·2kΩ	1	R21
10kΩ	1	R18
22kΩ	2	R10, 16
100kΩ	1	R11
180kΩ	1	R23
390kΩ	1	R26
1MΩ	1	R4

Capacitors

Disc Ceramic

1nF	1	C14
10nF	8	C2, 3, 5, 9, 13, 15, 19, 20

Polystyrene 160V 2%

4·7nF	2	C17, 18

Polyester Min. Dipped 250V

47nF	3	C1, 4, 16
0·1µF	6	C6, 10, 23, 24, 25, 26

Tantalum Bead

1µF 35V	2	C7, 11
2·2µF 35V	2	C8, 12

Electrolytic p.c.b. Type

1000µF 16V	2	C21, 22

Switches

Min. Toggle

s.p.d.t.	2	S1, 2
d.p.d.t.	2	S3, 4

Potentiometers

Min. Horiz. Preset

500Ω	1	R24
10kΩ	1	R5

Cermet Multiturn Top-adjust Preset

5kΩ	2	R19, 20

Cermet Top-adjust Preset

5kΩ	2	R8, 14

¼inch Spindle

500Ω	1	R28

Semiconductors

Diodes

1N914	5	D1, 2, 3, 4, 8
1N4001	4	D10, 11, 12, 13
Red l.e.d.	4	D5, 6, 7, 9

Transistors

BC108	1	Tr2
2N3819	1	Tr1

Integrated Circuits

NE566	1	IC5
NE567	2	IC2, 3
741	2	IC1, 6
74LS00	1	IC4
7805	1	IC7
7905	1	IC8

Miscellaneous

Mains transformer 6 + 6V 3VA p.c.b. mounting (RS207–829); 1A fuse and holder; Sockets (see text) (5); Metal case 200 x 125 x 75mm; Printed circuit board; Knob; Integrated circuit d.i.l. sockets 8pin (5), 14pin (1).

switches and sockets should be in lightweight screened cable and the type of sockets used can be either phono, miniature jacks or DIN to suit your tastes.

The prototype unit was housed in a metal case 200 × 125 × 75mm (Maplin BlueCase 222) but any similar metal case could be used.

Alignment

As no toroids or other wound components are used, setting-up is simply a matter of adjustment of the preset potentiometers. A minimum of test gear is required, this being a multimeter and a digital frequency counter capable of operating at between 1kHz and 2kHz. (The Soar FC-845 or similar is ideal.) A simple oscilloscope and an audio signal generator are useful but not essential.

The a.f.s.k. generator is set-up first to provide a pair of accurate signals for use in aligning the receive side.

Short the input to IC4a (SK2) to 0V and adjust R20 to give 1445Hz at the wiper of R28. Remove the short and set the output to 1275Hz using R19. Repeat the process until you achieve the two tones, accurately set, at the output. If you have a 'scope then the levels of the two tones can be balanced using R24. Note that R25 may need to be changed to achieve balance. If no 'scope is available then the output can be balanced by using the transmitter into a dummy load and adjusting R24 for equal power output with each tone.

Before setting up the p.l.l.s IC1 should be nulled. Short SK1 and adjust R5 so that the voltage at TPA is as near 0V as possible. A simple multimeter is suitable for this.

The two tones can be used to set-up the receiver p.l.l.s by connecting the a.f.s.k. output to the audio input (SK1) and adjusting R14 so that the red l.e.d. D7 comes on for 1445Hz. Repeat the process with the a.f.s.k. generator set for 1275Hz adjusting R8 until l.e.d. D6 comes on. Check that when D6 is on D7 is off and vice versa.

FOLLOW UP TO...

RTTY with the ZX81

by Dick Ganderton G8VFH

The RTTY terminal unit described in the June 83 issue of *Practical Wireless* was designed with ease of construction and alignment in mind. In general it succeeded but some constructors have reported difficulties, mainly in the receive section. These notes outline the possible problems and give the cures needed to overcome them.

Receive Circuits

Two problems have been noted, both of which affect the output on the screen. Not all constructors have suffered from these problems and to some extent they seem to be related to both the source of the 567 p.l.l. chips as well as the batch. The first problem seems to be related to a form of "jitter" caused by the v.c.o. in the chip taking a finite number of cycles to lock. This causes the output to "bounce" upsetting the computer sampling.

A cure can be effected by connecting a capacitor between pins 1 and 8 of the two 567s (IC2,3). The value of this capacitor will need to be determined empirically, but somewhere between 0.1µF and 0.22µF seems to be about right. The capacitor latches the output until the v.c.o. locks but the value must not be made so large as to latch the chip for longer than 20ms, otherwise you will make matters worse!

A related effect is false triggering caused by the output stage of the p.l.l. being too sensitive. The sensitivity of this stage can be adjusted by sourcing or sinking current at pin 1. Sensitivity can be reduced by connecting a resistor from pin 1 to the +5V rail but a better method is to use a preset potentiometer to allow you to vary the sensitivity as required. Fig.1 shows the mods described.

The components can be soldered to the leads of other related components and mounted on the top of the p.c.b. with their leads cut short. The settings of the two presets can be determined by recording a test tape from the a.f.s.k. and replaying it through the t.u., setting the presets to give a good printout on the screen.

Transmit Circuit

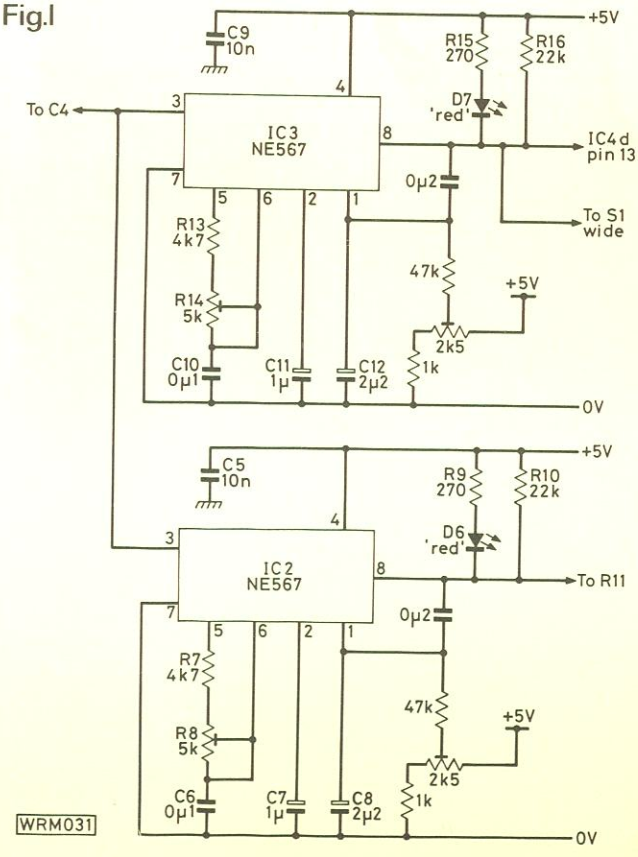
Frequency drift can be cured by replacing D8 (1N914) with a good quality, high-stability resistor of 560Ω. Note that C15 must be a 2 per cent polystrene capacitor, not a disc ceramic as in the components list. It may be necessary to change the value of R25, either up or down, to achieve a balanced sinewave output for the two frequencies.

Power Supplies

Some readers have had problems with the regulated supply rails oscillating. To prevent this either replace C25 and C26 with 1µF tantalum bead capacitors or solder the extra capacitors across C25 and C26.

I would like to thank those readers who have taken the trouble to keep me informed of their progress with this project and reported their success, or otherwise, with either my suggested mods or their own ideas.

Fig.1



RTTY with the ZX81

by Dick Ganderton G8VFH

Part 2

In the first part we looked at the design and construction of a terminal unit suitable for use with a microcomputer such as the ZX81 or Spectrum. Before we can use the t.u. with a computer we need some form of serial to parallel interface unit to allow the t.u. to conduct its two-way 'dialogue' with the computer.

Those readers who want to find out more about the theory behind interfacing should turn to books covering the subject. The interface board used for this project is the one designed by Scarab Systems and marketed by them as a kit of parts. The board was produced by Scarab Systems for use with their ZX81 RTTY software package and is simple, effective and easy to build.

Interface Construction

The interface is shown in the circuit diagram (Fig. 2.1) and uses the well-known 8251A programmable communications interface chip. It could be built on Veroboard if desired to keep the costs as low as possible. However the recommended method of construction is on the double-sided p.c.b. as shown in Fig. 2.2. This p.c.b. is available from Scarab Systems along with the RTTY software cassette.

Construction is started with the 23 through-board links and the TEST pin. Note that these must be soldered on both sides of the board. When you are satisfied that you have fitted all the links the i.c. holders can be fitted. If you want to save costs then these holders can be left out and the i.c.s soldered directly to the board although in the case of IC3 a holder is recommended.

The remaining components are then soldered in place taking care to solder both sides of the board where pads are provided. If a means of remotely changing the baud rate is required R2 could be changed for a potentiometer wired as a variable resistor.

Connections to the ZX81 are made with ribbon cable which can be soldered directly to the RAM pack or to the ZX81 p.c.b. depending on what you decide to do about re-housing the ZX81.

Setting Up

When you are satisfied that all connections have been properly made the baud rate can be set up. With S1 open, adjust R1 to obtain 2908Hz at the TEST point. Close S1 and adjust R3 to obtain 3200Hz at the TEST point. For other baud rates the frequency required at the TEST point is found from the following equation

$$f = 64 \times \text{baud rate}$$

If R2 has been changed to a variable resistor the baud rate should be set with it at mid-range to give a swing both above and below the nominal baud rate. You could, of course, calibrate the control and adjust it from the front panel of the computer keyboard.

Software

The program chosen for this project is the Scarab Systems ZX-RTTY program as this is readily available, proven and reasonably priced. The program offers six programmable memories, one of which transmits up to 255 RYs for tuning purposes while the other five can transmit individual messages, such as a CQ call, station details, test messages, etc. each containing up to 255 characters. Transmitted information is displayed on the v.d.u. screen in inverse format to distinguish it from received information.

The re-housed ZX81 with the Maplin keyboard. The diecast box houses the mains power supply, mains filter, ZX81, Ground Control 16K RAM board, Scarab interface board together with the various input and output sockets. The Maplin keyboard is a great improvement over the original ZX81 pressure-sensitive one

Reprinted from Practical Wireless, July 1983

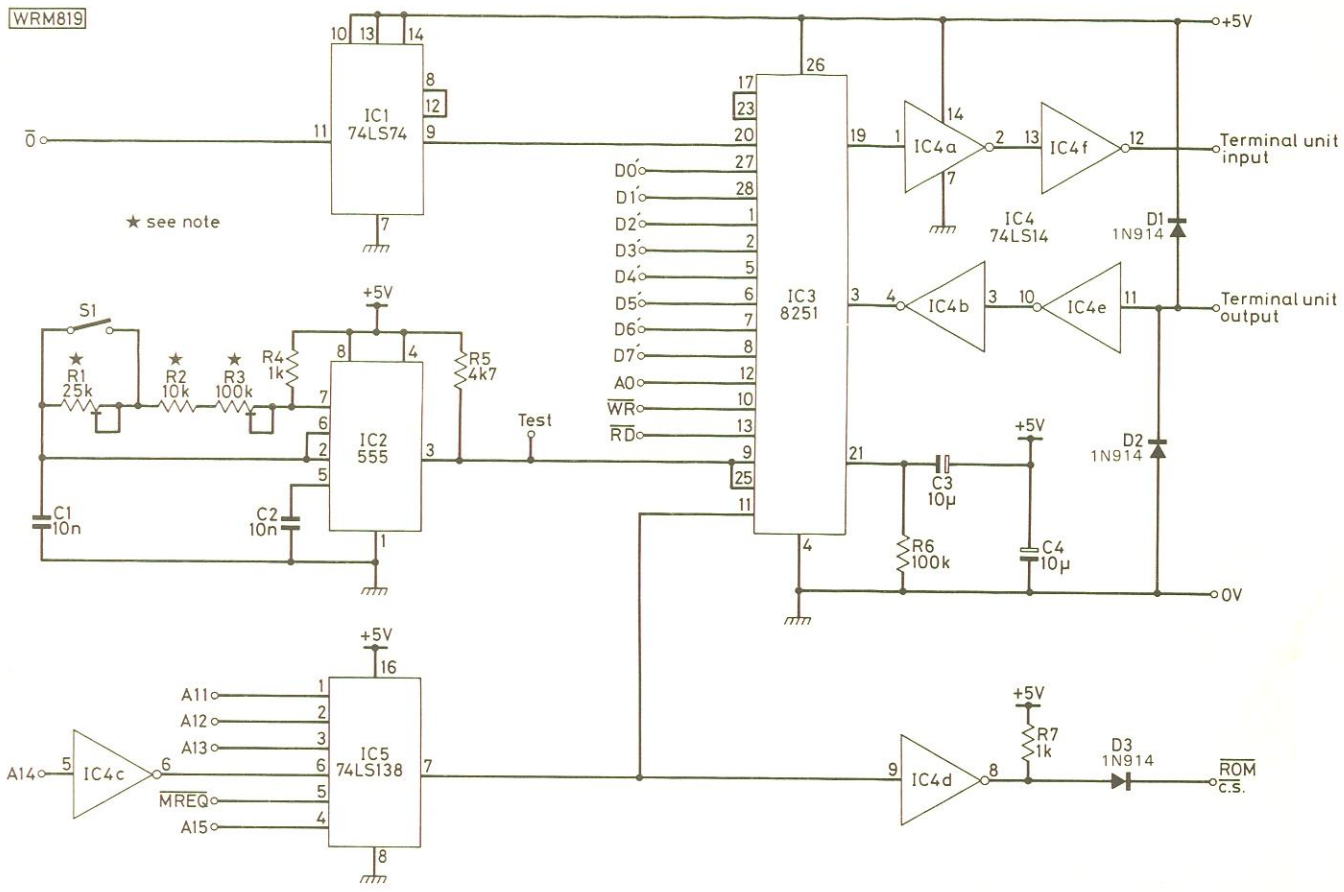


Fig. 2.1: Circuit diagram of the Scarab Systems interface. Resistor R2 can be replaced with a variable resistor to give a fine baud rate control if required.

CONSTRUCTION RATING Intermediate

BUYING GUIDE

The Scarab Systems software used in this project is available on a cassette from Scarab Systems, 141 Nelson Road, Gillingham, Kent ME7 4LT, Tel: 0634 575778. Price £9.75 incl. VAT and postage. The cassette with p.c.b. is also available from Scarab at £13.45 while the complete package including components is £25.15. The 16K RAM board used is available, cased, from Ground Control, Alfreda Avenue, Hullbridge, Essex SS5 6LT, Tel: 0702 230324. Price £19.95 inclusive. Ground Control can also supply their 16K RAM and IO board (p.c.b. only) together with full instructions at a special price for *PW* readers of £7.75. The keyboard used is from Maplin Electronics and is their LW72P at £19.95 in kit form. The case is their XG17T at £4.95.

The quoted price does not include re-housing the ZX81.

APPROXIMATE COST £26

★ components

Resistors

Carbon film ¼W 5%

1kΩ	2	R4, 7
4·7kΩ	1	R5
10kΩ	1	R2 (see text)
100kΩ	1	R6

Potentiometers

Min. horizontal presets

25kΩ	1	R1
100kΩ	1	R3

Capacitors

Polyester

10nF	2	C1, 2

Tantalum bead

10µF 16V	2	C3, 4

Semiconductors

Diodes

1N914	3	D1, 2, 3

Integrated circuits

NE555	1	IC2
8251A	1	IC3
74LS14	1	IC4
74LS74	1	IC1
74LS138	1	IC5

Miscellaneous

Min. toggle switch s.p.s.t.; Integrated circuit holders 8 pin d.i.l. (1), 14 pin (3), 28 pin (1); Printed circuit board (Scarab Systems); Through-board links, wire, ribbon cable etc.

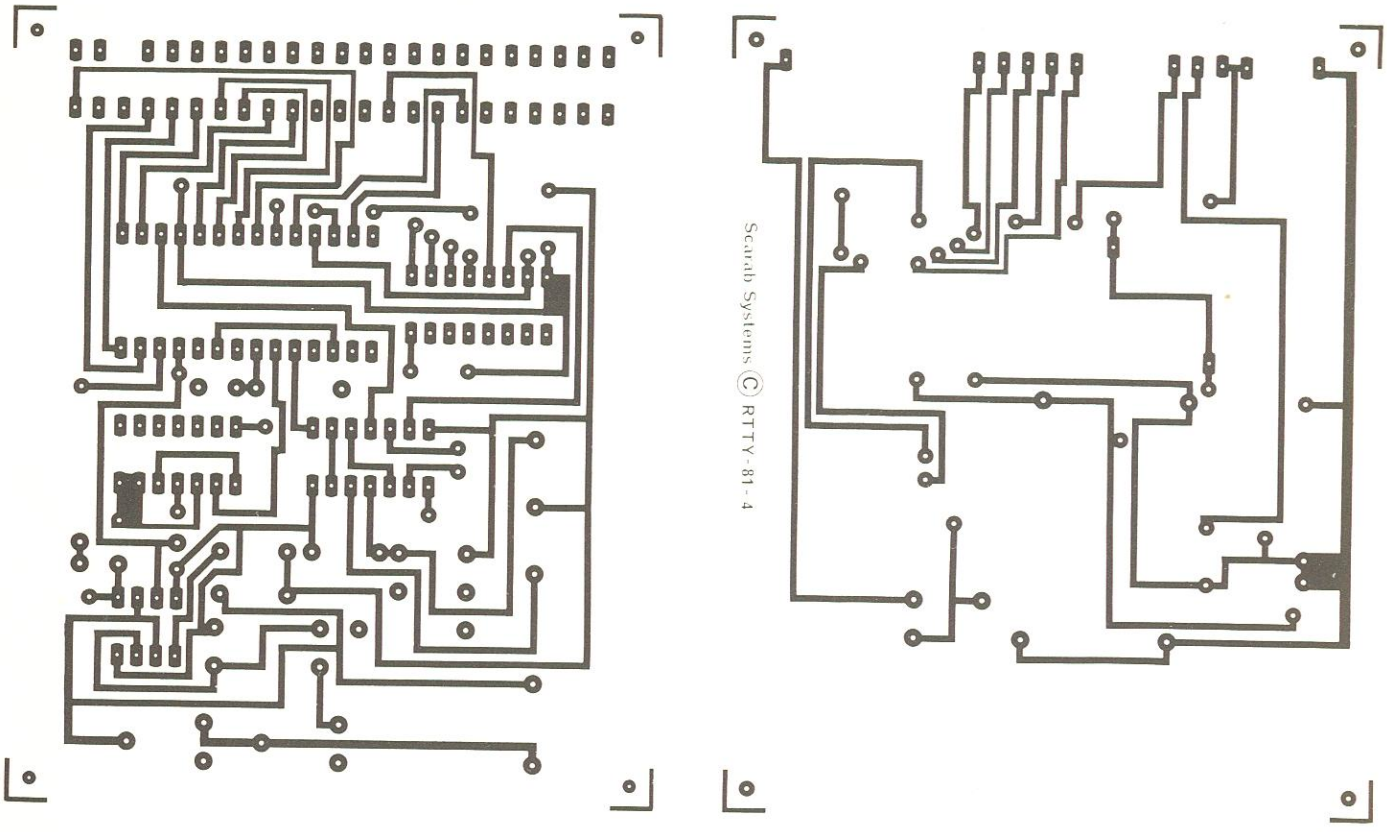
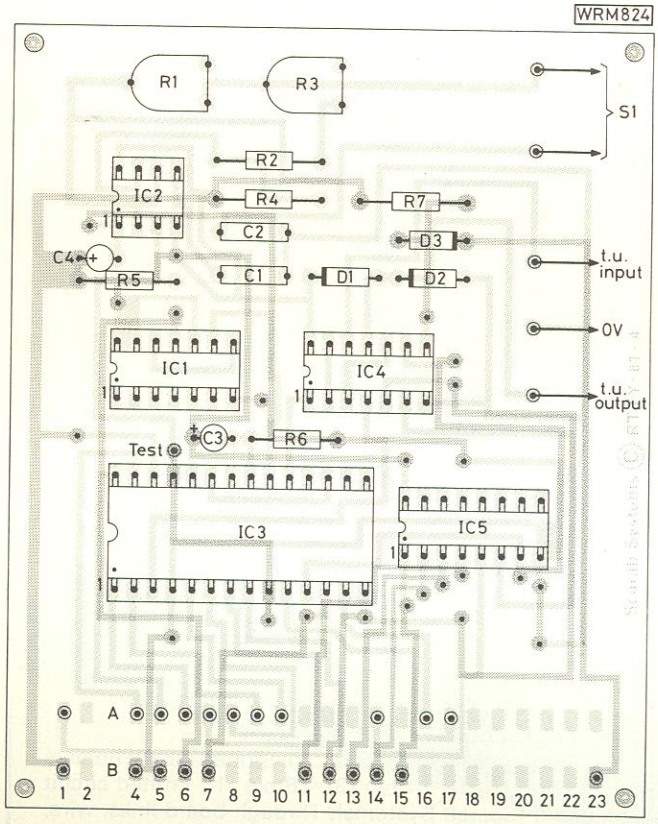
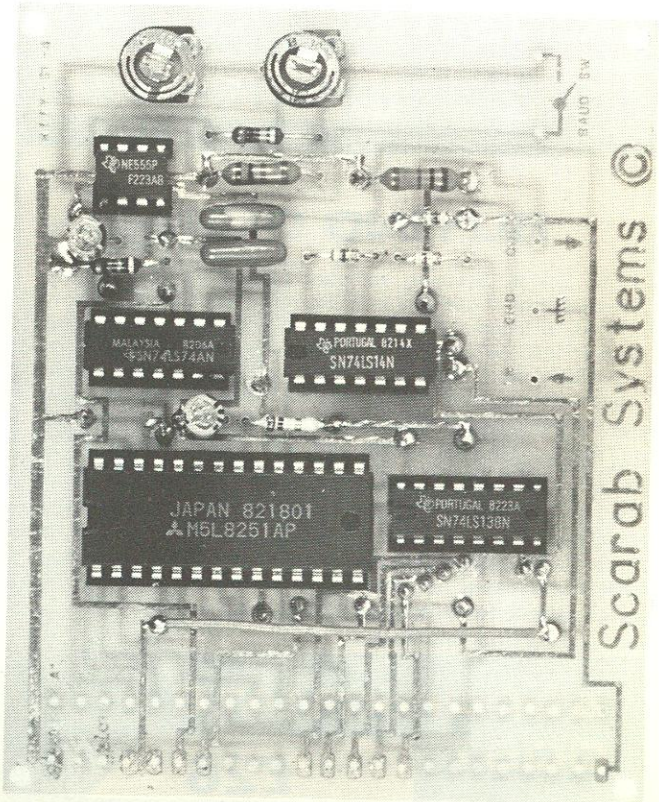


Fig. 2.2: Full-size copper track patterns and component placement for the Scarab Systems interface board





RTTY with the ZX81

Carriage return, line feed codes are automatically inserted during transmission after every 64 characters and text is written at the bottom of the screen and automatically scrolls upwards. All that remains to be done is to connect the interface board to your ZX81 and terminal unit, connect the t.u. to your transceiver, load the Scarab Systems RTTY program into the ZX81 and away you go.

QRM and Other Problems

All microcomputers produce some degree of QRM and the ZX81 is no exception. In some cases it is so bad that it completely swamps the transceiver while in other instances it is no problem at all!

It is well worth while, however, completely stripping the ZX81 out of its case and treating it as a plain p.c.b. which can be mounted into a screened metal enclosure together with a mains power supply, properly filtered, the RTTY interface board and the RAM pack.

While this is being done a better keyboard can be added, and this really is a must for RTTY operation. Also the various parts of the computer can be hardwired together for greater reliability.

I opted to use the Maplin keyboard which is reasonably priced in kit form, and has several useful features such as a SHIFTLOCK key, FUNCTION key and GRAPHICS 2 key to make life easier when loading or editing programs. The keyboard is connected to the computer via a ribbon cable and I used a 25-way plug and socket for this although it is not essential and the ribbon cable could be fed into the metal enclosure through a small slot.

The complete ZX81 with p.s.u. and RAM pack, etc. can be fitted into a large diecast box although this is a squeeze. The RAM pack used is the Ground Control 16K unit removed from its case and the edge connector unsoldered. The board is then connected directly to the ZX81 p.c.b. using either ribbon cable or a mixture of ribbon cable and rigid tinned copper wire to support the RAM pack board above the ZX81 board. To allow a printer or other peripherals to be fitted to the computer a slot is cut in the side of the box to allow access to the edge connector on the ZX81 p.c.b. For extra reliability I fitted a gold-plated edge connector to the board but this is an expensive luxury, and not really necessary.

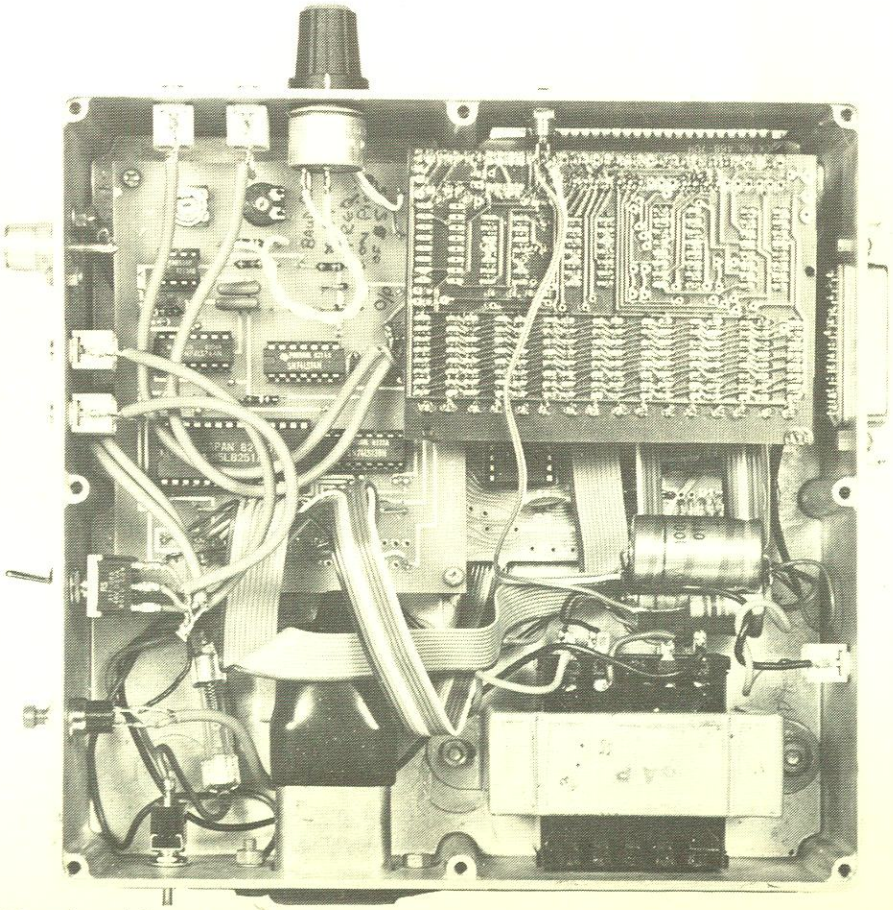
The ZX81 p.c.b. is attached to the box floor by two plastic pillars and the ZX81 heatsink which is joggled downwards and screwed to the box floor with some heatsink compound and a 6BA nut and bolt through a hole drilled in the centre of the heatsink.

Any metal enclosure could be used so long as it has a close fitting lid to keep it reasonably r.f. tight.

The mains p.s.u. could be the original Sinclair one, as long as it is the larger version capable of driving the printer as well as the computer, or it could be a new one built from a 9V 20VA transformer feeding a bridge rectifier with adequate smoothing. The mains input must be filtered as well as switched and fused.

Eliminating the problems created by the Sinclair edge connector by hardwiring, improving the heatsinking and screening the whole lot in a metal box improves the overall reliability and the computer can still be used by the kids to play games. The QRM is now low enough to be lived with and the Scarab Systems RTTY program works very well.

Scarab also produce an interface board and software for RTTY with the ZX Spectrum and the t.u. described in Part 1 is suitable for this. ●



The complete 16K ZX81 fitted into a large diecast box. The Scarab Systems RTTY interface board is fitted at the top left of the box while the Ground Control 16K RAM board, taken out of its plastics case is mounted directly above the ZX81 board in the top right corner. The mains power supply is in the bottom right of the box with the mains filtered plug centre bottom

air test

USER REPORTS ON SETS AND SUNDRIES

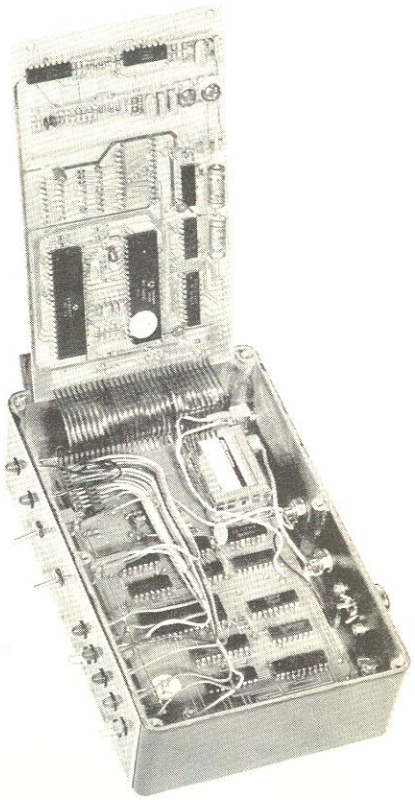
MM2000 RTTY to TV Converter

This unit, which has recently been designed and developed by **Microwave Modules,** is the quickest way for the short-wave listener and licensed amateur to receive RTTY, Murray coded and amateur band ASCII signals (the standard types of transmission used by amateurs). The Converter will receive and convert the four baud rates at present in use by commercial and amateur users. This receive-only device may subsequently whet the appetite for the transmitting scene with its exchange of contacts with other radio amateurs.

The MM2000 converts RTTY signals which then appear, suitably modulated, on u.h.f. TV channel 35 i.e., 583MHz in the commercial TV band. All that is required to use the unit is a signal from a suitable radio receiver and a d.c. supply of 12V. In the reviewers case the output from the receiver is taken from the "record" socket of a Trio R-1000 general coverage receiver. This output is at 30mV, more than ample for this unit; the signal is unaffected by the position of the volume control, so enabling monitoring via the speaker or headphones. One point found with the receiver is that the use of a filter, such as the Datong FL2, narrows the bandwidth and prevents the QRM, ever present on most amateur band RTTY. The minimum bandwidth is 2·7kHz, a little too wide for single-signal reception, which gives the best "copy" on the TV screen.

To return to the Converter. Signals from the receiver are filtered and amplified before being passed to the discriminator: accurate tuning indication of the signal being by means of two l.e.d.s. This method of alignment is very advantageous, when using an ordinary home constructed terminal unit and teleprinter, because overprinting will occur if the receiver is incorrectly tuned. In the Converter this is prevented by the incorporation of an automatic carriage return on RTTY signals. An innovation with this unit is the provision of an "auto-sensing" unit which enables it to sense the correct speed of the code transmission and indicate this on the appropriate l.e.d. for that speed. Manual override selection is also provided, if required.

Should an alternative, special code, be required, this is easily accomplished and involves re-programming of the internal EPROM by loading in a suitable program from cassette tape. So that the unit can be used in countries using positive sync. on the TV signal, a rear-mounted toggle switch is provided, giving instant access to either standard. This switch is a feature recently introduced by the manufacturers, to replace previous "hard-wired" internal links.



The picture information consists of 16 rows, each containing 64 characters and when using a 14in screen TV the characters are easy to read. The receiver used for driving the Converter should be stable and not prone to drift, otherwise continual adjustment of the tuning and b.f.o. will be required to retain the information. It is possible to copy both AFSK and FSK signals with this unit. These signals are easily recognisable: a warbling tone for AFSK and frequency variations for FSK. The actual frequency is varied, noticeably so when the receive b.f.o. is switched on.

Latest state-of-the-art techniques are used in the design of the Converter which employs two microprocessors and 21 i.c.s. All the circuits are built into a black enamelled aluminium die-cast box measuring 187 × 120 × 53mm, and mounted on two glass-fibre p.c.b.s using a plug-in connector technique which makes servicing that much easier.

continued on page 28 ▶▶▶

Reprinted from Practical Wireless, April 1981

air test

USER REPORTS ON SETS AND SUNDRIES

TELEREADER CWR-685

CW–RTTY–ASCII Communications Computer

The advent of the microprocessor has revolutionised the RTTY side of amateur radio and there are now several dedicated micros designed specifically for this purpose. The subject of this Air Test is the Telereader — a self-contained c.w., RTTY and ASCII terminal complete with video monitor screen.

The Telereader will inevitably be compared with the Tono Theta communications computer which we reviewed in *PW* May 1981. Although they are both aimed at similar markets they differ greatly in approach. The Tono Theta uses a separate video display (television) but is more sophisticated than the Telereader. The Telereader, however, is much easier to drive and is complete with built-in screen. It is more expensive than the Tono but leaves your domestic TV free.

Construction

The main unit is housed in a neat metal case with the main controls grouped sensibly on the left of the front panel and the video screen occupying the right-hand third of the panel. The controls are mostly push-buttons clearly labelled as to their purpose. There are four vertically operating slider controls at the left of the panel which are used to "tune" the Telereader for correct decoding of the signal. Above these four controls are four l.e.d.s which are not connected in any way with the controls. The l.e.d.s indicate power on, c.w. and mark and space. The latter two light up to show a mark or space and make tuning very easy when using the unit as an RTTY terminal.

The keyboard is a stand-alone unit and can be placed in the most convenient position on the operating desk. The key layout is conventional QWERTY and the action light and positive, making its use pleasant and easy. The video screen is clear and, although small compared to a normal portable domestic TV set, is easily read, the characters being clearly formed and well focused.

A handbook is supplied with the unit and takes quite a bit of understanding. No pictures of the front or rear panels are shown but as the controls and connections are clearly marked on the unit itself, and are fairly straightforward to use, the handbook did not prove to be too much of a drawback.

The review unit was used on the *PW* station at Breadboard '81 exhibition last November in conjunction with a Drake TR-7 h.f. transceiver. So pleasant was the Telereader to use that for most of the show GB2PW was on RTTY and contact was made with numerous stations as widely spaced as Japan, Israel, America and most of Europe.

The Telereader was also used with a Standard C58 to try some RTTY on 144MHz. The unit was easily connected to the mic socket to use a.f.s.k. and worked very well with this rig. The only problem arose from the low output power.

Memories

The memory was easily loaded with a selection of useful phrases and this made putting out a CQ call as simple as pushing the appropriate buttons on the keyboard. As the storage capacity of each of the six memories was limited to 32 characters more than one memory was needed to store a CQ call and station ident phrase. However, this did not prove to be a problem and storage was adequate.

Morse

The Telereader can be used to decode, and send, Morse and it was tried in this mode. The problem with the receiving mode is the usual one of setting the unit up to cope with the variations in amateur manual Morse. Whilst being easier to set up than some other machines the Telereader still lost sync occasionally.

The unit can operate at 3 w.p.m. to 50 w.p.m. with automatic speed tracking for c.w. The machine is equipped with a p.l.l. filter which has the effect of having a pass-band of ±80Hz with vertical sides to the filter characteristic. In other words signals within the pass-band are handled only when the p.l.l. is

in lock. The p.l.l. filter can be switched out.

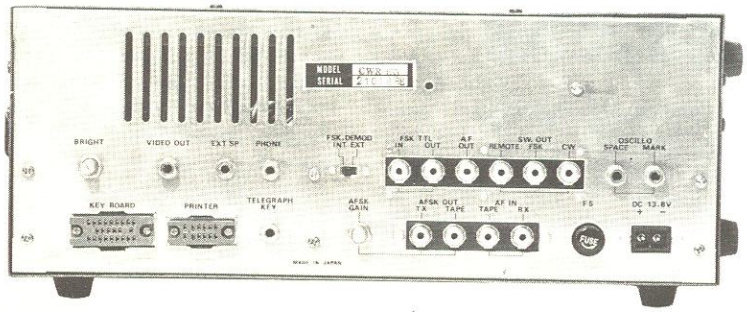
The Telereader is claimed to be able to interprete code with dashes ranging from 2 to 4 dots long. Over 4 dots long the dash may be correctly interpreted but the next code will probably be mis-coded. As the unit is computing using the previous eight characters it should only mis-code the occasional character.

When used as an RTTY terminal the MARK and SPACE l.e.d.s made tuning into a signal very easy and, coupled with the complete lack of mechanical clatter, made RTTY a pleasure. During operation the internal oscillator provides a pleasant sound which also helps with tuning and to some extent simulates the sound of a mechanical RTTY terminal without the mechanical clatter. This oscillator also gives audible Morse when decoding, or sending, this type of transmission.

In RTTY and ASCII modes the Telereader will operate at speeds of 45·45, 50·00, 56·88, 74·2, 110 and 300 bauds, with the highest speed only usable with an external modem or the TTL option input.

The rear panel carries all the input and output plugs, sockets and terminals including the connections for the nominal 12V d.c. supply at 1·6A. The handbook describes how to connect these to the receiver or transmitter and between each other for different operating modes. Frequency shift keying (f.s.k.) is the normal mode for input and output from the Telereader but f.s.k. TTL signals are also available at the back panel for use with an external modulator and demodulator. RTTY and ASCII can be transmitted using the AFSK OUT TX terminal (audio frequency shift keying) when using a transceiver not equipped for f.s.k. inputs. In this case connection is made to the transceiver's MIC terminals.

Connections are provided for a tape recorder and a printer (Centronics Compatible Parallel Interface) for hard copy output. ASCII codes are outputed to the printer. An oscilloscope can also be connected, in X-Y mode, to make tuning even easier than it is using just the l.e.d.s and oscillator output.



Handbook

The handbook, whilst adequate in terms of describing the operation of the Telereader, lacks several important features. There are no pictures of the controls or back panel connections and no circuit diagram of the complete unit. These omissions make understanding the fractured English a trifle difficult. The occasional mistake, such as *receiving* instead of *transmitting* in the description of the AFSK OUT TX function, does not help in working out the connections needed for your installation.

Our thanks to **Thanet Electronics, 143 Reculver Road, Beltinge, Herne Bay, Kent. Tel: 02273 63859** for the loan of the review model. The CWR 685 Telereader costs £699 inc. VAT.

MM2000 RTTY to TV Converter

▶▶▶*continued from page 26*

Connections to the u.h.f. TV monitor and audio input from the receiver are made by means of phono sockets. The power supply input of 12·5V, at approximately 1A, is by means of a DIN socket. Plugs are supplied with the unit for connection to these sockets.

Operating Procedure

Having powered-up, or cleared the system, the user is presented with a heading line containing the information *"Microwave Modules MM2000 programme 3·4"*. The 45·5 baud l.e.d. illuminates and the Converter is ready to receive Baudot coded signals at this rate. Pushing the SELECT button, steps the speed indicators through 50 and 75 bauds and eventually ASCII together with one of the three-speed l.e.d.s giving sequentially 110, 150 and 300 baud ASCII coded signals.

Further pushing of the SELECT button beyond the 300 baud ASCII point will force the unit into the AUTO SENSE mode for Baudot signals. At all stages user indications of state are provided by front panel mounted l.e.d.s.

During reception of noisy signals or with incorrect speed or shift settings, the microprocessor sampling the incoming signal may not verify the stop bit in its correct position. In these circumstances it will print a full stop on the screen. With the case control in the "on" position and when the unit is receiving Murray coded signals, the microprocessor controller will automatically force the letter shift after 15 consecutive different characters in figure shift. By switching the case control OFF this feature can be overridden, allowing response to letter and figure shift codes as normal.

To prevent the rapid replacement of a previously displaced page, the latest software allows only two consecutive carriage return line-feed operations, when receiving Murray coded signals.

The MM2000 is available at the VAT inclusive price of £169 direct from **Microwave Modules Ltd., Brookfield Drive, Aintree, Liverpool L9 7AN. Tel: 051 523 4011;** or through their many appointed agents.

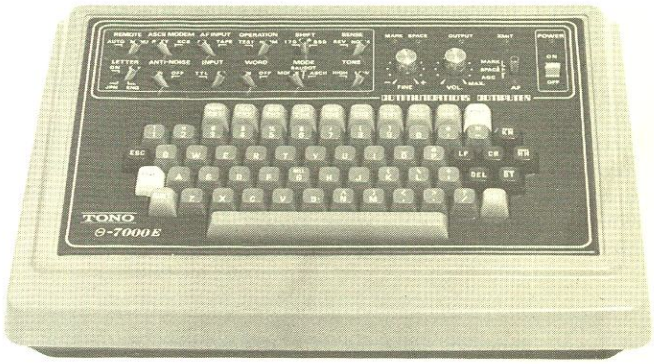
Reprinted from Practical Wireless

RADIO

SPECIAL PRODUCT REPORT

TONO θ-7000E

COMMUNICATIONS COMPUTER



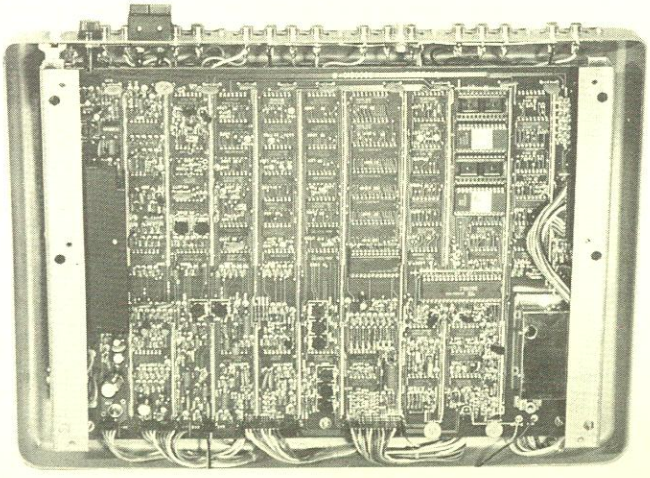
The Tono θ-7000E is a communications computer which will transmit and receive in c.w. (Morse), RTTY (Baudot) and ASCII, and display the messages on the screen of a v.d.u. or u.h.f. TV set, or as hard copy on a dot matrix printer.

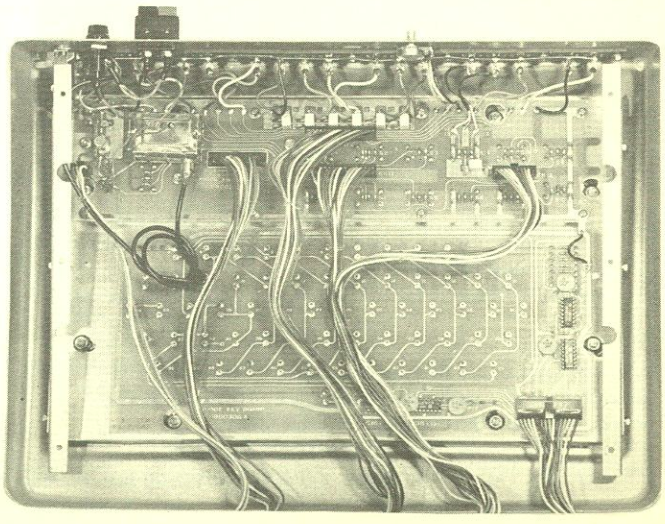
Your reviewer is competent in c.w. operation and typing, but has had no previous experience of the RTTY mode. Therefore, the manufacturer's instruction manual, in conjunction with the RSGB *Amateur Radio Operating Manual* and the recent *PW* series *Introducing RTTY,* had to form a primer in RTTY operation generally.

As will be seen from the specification table, the θ-7000E incorporates a very comprehensive range of features indeed. The instruction manual advises practice with a TV set before using with a transceiver, and this proved very necessary. In fact, most of the test periods were spent that way, and even after a couple of months of intermittent use, new features were still being discovered and explored. The instruction manual is written in "Oriental English" which although adequate in straightforward items, does get rather lost in the more sophisticated features, of which there are quite a few.

The most frustrating feature at first was that after following instructions for, say, entering copy into one of the memories, the machine would just sit there, defying all attempts to make it do what it was supposed to do, until it was eventually discovered quite by accident, that the Space bar acted as an "Execute" key, and caused the beast to spring into action when depressed. So far as I am aware this is not a normal feature of RTTY nor computer operation, but perhaps my lack of previous experience is letting me down here. Certainly there is no mention of it anywhere in the instruction manual.

The θ-7000E is housed in an attractive sheet steel cabinet which provides adequate screening so far as our tests showed, both **from** an adjacent 100W h.f. transmitter, and





The computer/control circuitry is housed on one large printed circuit board (left), while the switches and keyboard are mounted on two more (right)

to an adjacent h.f. communications receiver. All input and output connections are at the rear of the unit: spring terminals for the nominal 12V d.c. supply, ¼in jack for headphones, multi-way connector for the printer, and "phono" sockets for the rest.

Within the brief space of this review, I cannot hope to describe all the features of this very versatile unit. The Instruction Manual takes 30 pages to do so, regrettably somewhat inadequately. The Specification table summarises the main points, and the following notes add some detail:

Characters: "QBF" (Quick Brown Fox) and "RY" test messages are pre-programmed. The keyboard follows the standard typewriter layout.

Input: The required a.f. input level from a receiver is 50mV–1V. An anti-noise circuit eliminates garbled display in no-signal conditions.

AF Input Frequency: Accurate tuning of the incoming signals to the a.f. filters is aided by l.e.d. indicators.

Remote Control Keyer: Provides Transmit/Receive control of associated radio equipment, and can be automatic or manual.

Number of Characters and Pages: The first page can be divided in two. The lower half displays received signals, the upper half messages to be transmitted. These can be edited whilst receiving. A word-wrap-around function prevents the last word on a line being split in two in receive mode.

Battery Backed-up Memory: The messages put into Channels 1–6 can be repeated from 1–9 times at will. The message put into Channel 7 can be subdivided into four parts.

Buffer Memory: For composing and editing messages for transmission. Can be used whilst simultaneously receiving.

Output for Oscilloscope: Provides "cross" tuning pattern. Output level 1·2V p-p into 1MΩ minimum.

AF Output: The internal loudspeaker is muted when headphones are plugged in.

For anyone trying to learn or improve their Morse Code, the θ-7000E can also form a useful tutor/exercise aid. It will produce individual characters at various speeds at the press of a key. It will decode Morse from a receiver or tape to provide a simultaneous visual readout. It will act as a "listener/decoder" to Morse which you send to it by means of a key plugged into the back of the unit, producing clean copy on the TV screen if you have a good "fist", or gibberish if you don't (well—I never did think my sending with a mechanical bug-key was very good!). It will even play back to you, in perfect Morse, what it thinks you just sent to it. I don't suggest you go out and buy one just for this purpose, but if you want it for RTTY, then you get that lot thrown in, as it were.

Note that under the terms of the current UK Amateur Transmitting Licence, Morse (c.w.) operation is not permit-

★ specifications

Code:
CW (Morse), RTTY (Baudot Code), ASCII

Characters:
Alphabet, Figures, Symbols, Special characters

Communication Speed:
CW receiving: 25–250 Characters/Min. (Automatic follow)
CW transmitting: 25–250 Characters/Min.
Weight: 1:3–1:6
RTTY and ASCII: 45·45, 50, 56·88, 74·2, 100, 110, 150, 200, 300 Baud (Fine adjustment available)

Input:
AF Input: CW, RTTY, Input Impedance 500Ω
ASCII, Input Impedance 100Ω
TTL Level Input (common to CW, RTTY, ASCII)

AF Input Frequency:
CW: 830Hz
RTTY: Mark: 1275Hz (Low Tone), 2125Hz (High Tone); Shift: 170Hz, 425 Hz, 850Hz and Fine Tuning (or reverse)
ASCII: Mark: 2400Hz, Space: 1200Hz (or reverse)

Output:
Keying: CW Keying (positive) 100mA, 300V
CW Keying (negative) 100mA, 300V
FSK Keying 100mA, 300V
FSK Keying (ID) 100mA, 300V
AFSK Output Impedance 500Ω (common to CW, RTTY, ASCII)
TTL Level Output (common to CW, RTTY, ASCII)

AFSK Output Frequency:
CW: 830Hz
RTTY: Mark: 1275Hz (Low Tone), 2125Hz (High Tone); Shift: 170Hz, 425Hz, 850Hz (or reverse)
ASCII: Mark: 2400Hz, Space: 1200Hz (or reverse)

Display Output:
UHF, Output Impedance 75Ω
Composite video signals, Output Impedance 75Ω

Interface for a Printer:
Centronics parallel compatible

Remote Control Keyer:
Capacity: 300mA, 50V

Number of Characters and Number of Pages to be displayed:
512 characters (32 characters × 16 lines)/page × 2 pages (Total 1024 Characters)

Battery backed-up Memory:
64 characters × 7 channels

Buffer Memory:
53 characters

Output for Oscilloscope:
Output Impedance 200kΩ

AF Output:
150mW, Output Impedance 8Ω

Power Supply:
DC +12V, 1A

Dimensions:
400 × 300 × 120–57mm

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ted by Class B licence-holders, and this restriction applies even to the use of a device such as this.

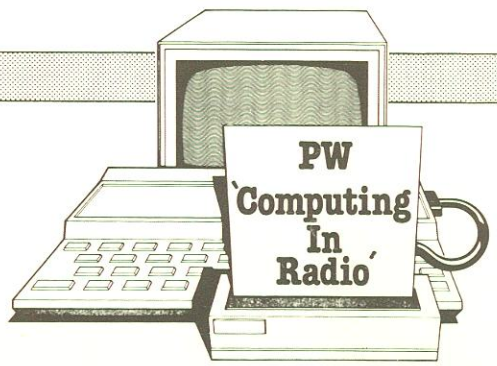
Results

Stability and reliability proved excellent, and we used the review unit for the somewhat unusual task of decoding and displaying a message for visitors to our stand at Breadboard '80 Exhibition. The message was recorded in Morse on a standard Compact Cassette, and replayed more or less continuously for over nine hours a day for five days, without a hiccup by the computer. Tests on the air proved highly successful once the basics had been mastered. My appreciation to several amateurs, especially G4GTH, who bore with me so patiently in my tests. The unit's ability to extract and decode a signal beset with QRM on the h.f. bands was at times quite amazing. Similar results were obtained with weak signals on 2m f.m. We understand that the θ-7000E is widely used on commercial h.f. links, which obviously says much for it.

The θ-7000E provides, in conjunction with a v.d.u. or TV receiver, a versatile telegraphy terminal unit, with dedicated programming for operation in the three modes, with auxiliary symbols and functions, and some user-programmable memory for brief standard messages. A similar range of functions could probably be obtained from a micro-computer plus a range of software and interface hardware at a comparable overall cost. Which solution is most attractive will depend very much upon the circumstances and requirements of the individual user.

The Tono θ-7000E has recently been superseded by the Tono θ-9000E price ~ £669 inc. VAT. This review of the 7000-E has been included as there will be many around on the secondhand market. The 9000E is described as a "highly sophisticated and amazingly improved 7000E'. A word processor is built into the 9000E and graphic patterns drawn by light pen on a c.r.t. display can be sent or received at high speed. The battery-backed-up memory has been expanded to 256 characters by 7 channels. The 7000E was loaned for the review by **Thanet Electronics, 143 Reculver Road, Beltinge, Herne Bay, Kent, telephone 02273 63859** who can also supply the 9000E. ●

from RAMTOP NINE



REVIEW—G3WHO RTTY PROGRAM

I think Peter is the sort of chap who would probably renew his *RAMTOP* subscription at the end of the year whatever I said about his RTTY program so you needn't think I'm creeping when I say that it's good: it's very good. I've been using it with the *RAMTOP* KTU terminal unit for a couple of months now and, in its present form, I can find little about it that I would like changed. Earlier versions of the program lacked one or two refinements now included and it's hard to see what more Peter can do to bring about further substantial improvement.

The program is currently available on tape or disc. Peter has deliberately made the program easy to copy so that one's own "customised" version can easily be kept. Various alterations might be made to the original by an individual user. Each function key, for example, can call a pre-programmed message, switch between TX and RX and so on. The owner's callsign can be programmed in and called by a single symbol in the text. When these adjustments have been made to the BASIC part of the program, the user will want to record the result for use and he'll probably want to put away a security copy.

When the program is running, the screen is split into two halves by a horizontal line. Received text appears above the line and text for transmission can be prepared below the line. The 80 column mode allows plenty of space and is not too difficult to read on an ordinary black-and-white portable television. Special characters can be typed into the text to force new lines, to print the current clock time (initiated by the user after loading the program), to send a c.w. identification and so on. Two volatile memories can also be recalled in this way. "Volatile" simply means that up to 12 characters can be stored in each and changed easily; this is in contrast to the pre-programmed messages. One obvious use is for storing the callsign of the other station in the current QSO. This can be "captured" from the received text on the screen and stored in memory 1 by holding down the <CTRL> key and pressing <D>. Another control code opens up the memory for the direct entry of a string. Others clear each half of the screen, toggle between 50 and 45.45 baud or between TX and RX and so on.

My copy of the program is set up so that a complete CQ text, my name and QTH details and my working conditions are each available at the touch of a function key. My F8 clears the TX screen and sets up a carriage return and a few RYs ready for transmitting together with anything else I can get typed in before the other end stops sending. His message, of course, is still appearing at the top of the screen while I'm trying to fill the bottom. I can then sit back until it's time to press the TX key (my F9). I can then continue typing in the end of my message while the first part is being sent. The transmitted audio tones are generated inside the computer itself.

I know there are other programs available which I've not had the chance to use and so I'm not going to make any claims for Peter's program over against the merits of those. All I know is that I like it and have had lots of successful RTTY contacts using it with the *RAMTOP* KTU interface.

If you've got a BBC B then you could do a lot worse than build the KTU and send off for a copy of this program. I reckon it's good value.

Available from **Dr. P. J. Harris (G3WHO), 10 Appleby Close, Great Alne, Alcester, Warks, B49 6HJ** price £7·50 on cassette or £9·50 on disc incl. p&p.

This review, by G4NWH, is reprinted, with permission, from the September issue of *RAMTOP*.

AEA MBA-RO CW/RTTY Reader

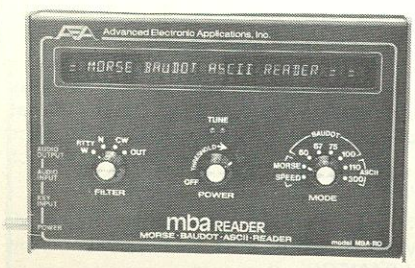
The MBA-RO, manufactured by Advanced Electronic Applications Inc., is one of the most recent arrivals among the ranks of devices for decoding and displaying telegraph signals in Morse, Baudot or ASCII codes. It uses a 32-character alphanumeric vacuum fluorescent display, with blue 14-segment characters 7·4mm high. The characters proceed from right to left across the screen during copy. A microprocessor plus 17 other i.c.s are used in the unit.

In the Morse mode, the MBA-RO will automatically track over a speed range 3–99w.p.m. either audio signals from a receiver output or else the output of a straight, "bug" or electronic key (for sending practice or monitoring). In the audio input circuit an 800Hz filter with 100Hz bandwidth gives added protection against interference, but this can be switched out if necessary. The speed of the Morse code signals fed into the unit can be indicated on the two right-hand characters of the display, this being a "by-product" of the speed tracking system, which measures the length of each dot and dash element, ignoring inter-character spaces, and updates only between words.

Both the audio and key inputs are on 3·5mm jacks, and a similar jack, labelled AUDIO OUTPUT and connected in parallel with the AUDIO INPUT, gives an easily accessible connection for monitor headphones.

In the Baudot mode, speeds of 60, 67, 75 and 100 w.p.m. can be selected, corresponding to Baud Rates of 45, 50, 56 and 75. Filters are provided for narrow shift (800Hz "mark", 970Hz "space"), commonly used for amateur operation, and wide shift (800Hz "mark", 1225Hz "space"), used commercially. In the ASCII mode, 110 and 300 Baud signals can be copied.

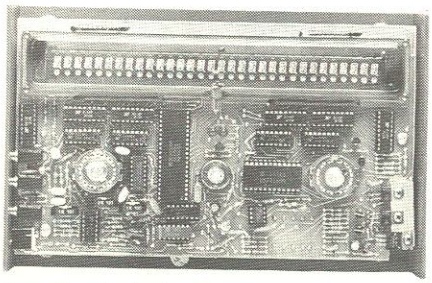
Tuning in all modes is aided by two



l.e.d. indicators. The THRESHOLD control on the reader is first adjusted so that both l.e.d.s are extinguished with no incoming signal. Then, the receiver tuning and audio level should be adjusted until both l.e.d.s flash in time with the signal for Morse, or so that one is continuously lit and the other flashes in time with the signal for RTTY modes.

Obviously, with 100Hz-wide filters, careful tuning and a stable receiver are called for, and some operating practice is needed for good results, particularly on RTTY. Incidentally, other RTTY shifts can be accommodated by setting the FILTER switch to the CW position and using the "mark" signal only, with reduced noise immunity.

No indication of the input signal level required is given in the manual, other than a comment that connecting the unit across a loudspeaker output may mean that the audio level to the speaker has to have attenuation introduced to give a comfortable listen-



ing level. I found that a nominal 400mV output from a receiver tape-recorder jack was not quite enough to give 100 per cent copy. Connecting the unit to a headphone output with 'phones in parallel required a deafening level for consistent decoding, and is not really a usable method.

The review unit was tested on the h.f. and v.h.f. bands with satisfactory results on all modes. It doesn't take too kindly to a sloppy fist on c.w., but then what automatic decoder does? It's a very stern critic if you practice your Morse by plugging in a key and sending to it! As well as the normal alphabet and numerals, it recognises 7 accented letters, 11 punctuation marks and 7 procedure signals among its Morse character set, and copes with 13 additional Teletype characters on RTTY.

The MBA-RO has all its components mounted on a single p.c.b. housed in a substantial two-part metal case measuring 48 × 224 × 150mm. It weighs around 0·9kg. Power requirements are 13V (±3V) at 500mA d.c. The instruction manual tells you how to connect up, check out and operate the unit, and includes a full circuit diagram.

The AEA MBA-RO is priced at £175 including VAT (post, packing and insurance £2.50) and is available from the importers, **ICS Electronics Ltd., PO Box 2, Arundel, West Sussex BN18 0NX, telephone 024 365 590,** to whom we offer our thanks for the loan of the review unit.

Geoff Arnold

SOAR FC–845 Digital Frequency Counter

Following on the heels of the FC–841 (reviewed in our August 1981 issue) comes this new instrument covering 5Hz to 160MHz. There are two frequency ranges—5Hz to 2MHz and 1MHz to 160MHz, and two gate times 0·01s and 1s, giving a resolution of 1Hz below 2MHz and 100Hz up to 160MHz.

A $4\frac{1}{2}$-digit, 7-segment l.e.d. display is used, so that for most accurate measurement of frequencies above 20kHz, you need to take two successive readings. The same principle was used in the FC–841, but for the benefit of those who haven't come across it before, it works like this. You want to measure the frequency of a transmitter operating on the 14MHz (20m) band, picking off a sample of the output in some way. Key down, and with the FC–845 switched to the HI frequency range and 0·01s gate time,

the display reads "14.04". Go to the 1s gate time and the display now reads ".0375". The "375" replaces the final "4" of the first reading, and the frequency is 14·0375MHz. An "overflow" indicator would have been flashing when you were taking the second reading, to remind you that you had, in effect, "lost" some digits off the

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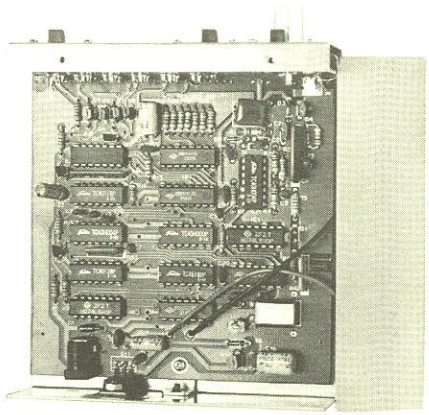
left-hand end of the display. A couple of l.e.d.s show you which frequency range you're on, and these flash if the batteries are getting low. The decimal point on the display flashes in time with the counter gate.

Power is either from internal batteries (six R6/HP7 cells) or an external 7·5V d.c. supply at about 130mA maximum. A word of warning when using an external supply—the rear-panel input connector is a coaxial type, recessed inside the metal case. The sleeve of the connector is the positive, and the counter case is negative. Should you use one of the long-reach plugs with a 14·3mm sleeve (as I did) the result is a "splat" and an unhappy p.s.u. if the plug waggles and touches the case. The maker's manual specifies a 9·5mm sleeve (short-reach) plug, and you should take heed!

The input connector is a BNC, the input impedance being approximately 150kΩ/35pF on the LO range and 2·5kΩ/15pF on the HI range. Sensitivity is specified as 35–50 mV on the



LO range and 30–50mV on the HI range, needing more input towards the band edges in each case. These figures were all bettered very comfortably indeed on the bench, and the FC–845 also showed itself very tolerant of modulation, either a.m. or f.m., on the signal to be measured.

Accuracy, like that of the FC–841, was quite remarkable. The makers specify ±50p.p.m. from 0–40°C, and importers Holdings of Blackburn reckon ±3p.p.m. at room temperature. Checked against an ovened 1MHz standard over 24 hours in a room varying from 15° to 21°C, the readout varied by only 2Hz. The readout is not all that bright, and you'll need to find a shady corner, away from sunlight or a bench lamp.

The unit measures 36 × 111 × 125mm excluding controls, feet and tilt stand, and weighs 420g excluding batteries.

The Soar FC–845 with batteries and input lead costs £65·00 including VAT (post and packing £1·50), and a suitable mains p.s.u. is available for £5·50. Further details from **Holdings Photo-Audio Centre, Mincing Lane, Darwen Street, Blackburn, BB2 2AF, Telephone 0254 59595,** to whom we offer our thanks for the loan of the review sample.

Geoff Arnold